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Using a Multi-Scale Life-History Approach to Explore Occupancy Patterns of Pond-Breeding Anurans in Eastern Virginia

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A Thesis presented to the Graduate Faculty
of the College of William and Mary in Candidacy for the Degree of
Master of Science

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This Thesis is submitted in partial fulfillment of
the requirements for the degree of

Master of Science

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ABSTRACT

Although the role of scale is recognized as an important factor in the understanding of species-habitat relationships, the application of multi-scale analyses in studies are rare. Observations of habitat effects at one scale can cause faulty inferences if unmeasured variables at other scales are driving population processes. The life-history of pond-breeding Anurans encompasses three distinct areal scales relating to the processes of breeding, migration, and dispersal. My study examined the relationship between the spatial variation in breeding site occupancy of 9 pond-breeding Anurans in eastern Virginia and covariates hypothesized to be important at the life-history scales of breeding, migration, and dispersal, as well as within a multi-scale model. Covariates measuring available habitat were included in the breeding and local scale models, while measures of anthropogenic disturbance (disruptors of connectivity) and source habitats were used in the dispersal scale model. The performance of scale and multi-scale models was tested using the area under the receiver operator characteristic curve. I found that pond or wetland occupancy by Anurans was dependent on variables at multiple spatial scales relevant to their life-history stages and that a multi-scale analysis was often the best method for explaining variation in occupancy. The smallest, breeding life-history scale was generally a poor predictor of site occupancy in most species and was significantly worse or no better than the migration and dispersal scales at explaining patterns of Anuran site occupancy. Species' models for the migration and dispersal life-history scales performed equally well in all species suggesting that both landscape scales are important drivers of site occupancy by Anurans. The multi-scale model was generally a strong predictor of site occupancy and had significantly better performance than one or more life-history scale models in 7 species. Additionally, the observed relative effect size of covariates changed between the single life-history scale and multi-scale models, indicating that conclusions made at one scale can misconstrue the underlying drivers of a system and highlights the need for multi-scale modeling to avoid spurious effects.

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INTRODUCTION

The majority of modern day species endangerment is attributed to anthropogenic disturbance (Wilcove et al. 1998). Of the threats to species, habitat loss is the leading cause of global biodiversity declines and in the United States urbanization is the primary reason for land conversion and habitat loss (Sisk et al. 1994; Czech 2004; Brown et al. 2005). Habitat loss not only reduces area, but fragments remaining habitat into smaller patches. Understanding the effects of fragmentation requires a comprehensive evaluation of habitat patches in the framework of the surrounding landscape (Fahrig 1999). An effective species conservation strategy requires habitat protection that assesses and manages habitat patches in the context of the greater landscape (Lindenmayer et al. 2008).

The need to evaluate and manage habitat at a landscape level, highlights the important role scale plays in ecological research and conservation. Scale is defined as the grain and extent used to describe a landscape (Turner 1989), but for the remainder of this paper, I will use the term scale to solely describe a landscape's extent. Traditionally, conservation strategies have operated on relatively small spatial scales, such as the scale of the pond or wetland for pond-breeding Anurans (Semlitsch 2008). However, species-habitat relationships are scale dependent and observations of habitat effects at one scale can cause faulty inferences, scale mismatching, if unmeasured variables at other scales are driving population processes (Levin 1992). The mismatching of scales can result in failed conservation strategies that do not address the entire life history of an organism and the scales at which it responds. Modern conservation strategies and research have recognized this problem and the prevalence of multi-scale approaches is increasing (Graf et al. 2005; Cabeza et al. 2010; Razgour et al. 2011).

The efficacy of multi-scale analyses will be dependent upon the scales chosen. At the species level, multi-scale models must include scales that address each stage of an organism's life history, what I call life-history scales (Freemark et al. 2002). A classic example of the need to address all life-history scales of a species can be observed in the history of research and conservation of forest-breeding Neotropical migrant songbirds. Early research suggested that songbird populations were responding negatively to land cover change in their North American breeding habitat even though resident species with similar breeding behaviors were not in decline (Finch 1991). It was only when researchers began to include the wintering scale of the Neotropical birds' life histories in their analyses did the real source of their population declines, tropical deforestation, become illuminated.

While not transcontinental, even species with limited mobility that function at relatively small spatial extents will have life histories that require examination across multiple scales. Pond-breeding Anurans have bi-phasic life histories that require both aquatic and terrestrial environments for different life stages (Werner and Gilliam 1984). At the smallest local scale (breeding scale), Anurans require aquatic habitats that facilitate breeding and larval development. During the non-breeding season, a shift in scale occurs from the local breeding site to the surrounding landscape (migration scale) as Anurans migrate into the terrestrial environment to access foraging habitats, summer refugia, and overwintering sites (Semlitsch 2008). Finally, the population dynamics of immigration and emigration from dispersing juveniles occurs at a third, broader landscape scale (dispersal scale; Semlitsch 2008). Populations isolated from the beneficial effects of dispersal are vulnerable to environmental and demographic stochasticity, as well as lower genetic variability, all of which can synergistically increase the probability of extinction (Gilpin and Soulé 1986).

For dispersal and migration to be successful, there must be adequate connectivity within the landscape. Landscape connectivity is defined as "the degree to which the landscape facilitates or impedes movement among resource patches" (Taylor et al. 1993). This definition indicates that connectivity is a function of landscape configuration (i.e. land cover patch size and arrangement) and composition (i.e. diversity of land cover), and species vagility, and as such, is critical to maintaining viable populations. If resources patches or neighboring populations are configured at distances greater than the maximum dispersal distance of a species, then migration or dispersal will be unsuccessful. Additionally, as land cover composition in the landscape varies, it can be assumed that connectivity will vary as well (Goodwin and Fahrig 2002). Some land covers provide a high degree of connectivity whereas others impede or act as complete barriers to species movement. Studies have demonstrated that many anthropogenic land covers and features negatively affect landscape connectivity. Vertebrate species are negatively influenced by roads and associated traffic volume either from vehicle related mortalities or the animal's avoidance of roads (Alexander et al. 2005; Koivula and Vermuelen 2005; McCown et al. 2009). Anthropogenic land cover types including agriculture, urban, suburban, and other disturbed land covers in the landscape are known to impact landscape connectivity for small mammals and birds (Verbeylen et al. 2003; Castellon and Sieving 2006; Umetsu et al. 2008).

Federal and state governments have recognized the necessity of wetlands and implemented regulations for their protection (e.g. Executive Order 11990, Protection of Wetlands), however, these regulations often only apply to the scale of the aquatic habitat or to small terrestrial buffers around the wetland. While these regulations are effective at protecting water resources, they may be inadequate for the conservation of many semi-aquatic, obligate, wetland species if they do not match the terrestrial landscape scale at which a species functions (Semlitsch and Bodie 2003). The objective of this study was to help inform the scales of conservation required by identifying the spatial extents and landscape features that influence pond and wetland occupancy by breeding Anurans found in eastern Virginia. I examined the relationship of the spatial variation in breeding site occupancy to covariates hypothesized to be important at three life-history scales: breeding, migration and dispersal. For the breeding and migration scales I used measures of habitat availability. For the dispersal scale I used measures of anthropogenic disturbance that could affect connectivity and the availability of potential source habitats for colonizing emigrants.

METHODS

Study Area

My study area (3578 km^2; Lat: 37.45, Long: -77.10) encompasses the Virginia Peninsula and ranges west into the Richmond municipal area. The Virginia Peninsula is contained within the Chesapeake Bay Lowlands Ecoregion as delineated by The Nature Conservancy, with portions of west Richmond overlapping with the Piedmont Ecoregion (Figure 1; Olson and Dinerstein 2002). Encompassing both the Richmond and Hampton Roads metropolitan areas, my study area features a gradient ranging from urban centers of high population density to low density rural areas. The study area is bounded by the Chesapeake Bay to the east, the York River to the north, and the James River to the south. I stratified my study area by partitioning it using the smallest U.S. Geological Survey Hydrological Unit Classification (HUC 12) (Seaber et al. 1987), and classified each HUC according to four housing density categories, a surrogate for urban density (Radeloff et al. 2005): very low >= 0 and < 6.18 houses/km^2, n = 7; low >= 6.18 and < 49.42, n = 29; medium >= 49.42 and < 741.32, n = 16; and high >= 741.32, n = 5. Housing density was calculated from the 2000 U.S. census data (U.S. Census Bureau 2010).

Survey Site Selection

Survey sites were defined as ponds or wetlands where Anurans potentially breed and were randomly selected from each stratum housing density category from an updated National Wetland Inventory (NWI; U.S. Fish and Wildlife Service 2010) spatial data set prior to the first field season in 2011. I updated the NWI by hand-digitizing aquatic bodies not captured by the NWI in a Geographic Information System (GIS) (ESRI 2009) based on 2009 Virginia Base Mapping Program (VBMP) aerial imagery (Virginia Information Technologies Agency 2009). To ensure survey site independence, selected sites were a minimum of 1 km apart, a value chosen based on the estimated maximum migration distance of most Anuran species (Semlitcsh 2008). I delineated survey sites in a GIS by first randomly selecting ponds within the very low housing density category that were at least 1 km apart. I then chose another set of random survey sites in the low housing density category, again ensuring that inter survey site distance was $\geq$ 1 km. I repeated this procedure for all remaining housing density categories resulting in a set of potential survey sites. Potential survey sites were evaluated prior to the field season for accessibility. If a survey site was deemed inaccessible due to logistical reasons (e.g. safety or private property), another breeding site was randomly chosen. I used the Pearson's chi squared test to test if the sampling distribution among housing density strata was even (Quinn and Keough 2009). To test whether or not the survey sites were randomly distributed throughout my study area, I used the Average Nearest Neighbor ratio in ArcGIS's Spatial Statistics toolbox (ESRI 2009).

Calling Surveys

Calling surveys were used to assess the presence of Anuran species at survey sites. This methodology takes advantage of the breeding strategy of Anuran species in which males assemble at breeding ponds and vocalize to establish territories and attract females. Vocalizations of each species are unique and allow species to be readily identified by surveyors. There are 20 candidate frog and toad species in the study area (Table 1; Virginia Department of Game and Inland Fisheries 2012).

Calling surveys were based on a modified North American Amphibian Monitoring Protocol (NAAMP; Weir and Mossman 2005). In the Virginia coastal plain region, the NAAMP protocol stipulates that surveys are conducted from February through July to capture the maximum breeding activity of the three breeding periods of early (February 16 to March 17), mid (April 20 to May 19), and late (June 15 to July 14) season breeding Anurans (Garrett 2002). In contrast to a single visit as specified by the NAAMP, survey sites were surveyed three times during each of three breeding periods.

The nightly survey period ranged between 30 minutes after sunset and 1:00 AM. For most species, studies have found calling activity to be highest during this time period (Bridges and Dorcas 2000). For a five minute period, I recorded all species heard at a site. Environmental variables are also known to influence Anuran calling behavior and affect an observer's ability to detect calling individuals (Dorcas et al. 2009). To account for this variability, biotic and abiotic parameters used in the NAAMP protocol were recorded as survey-specific detection covariates (Table 2). Surveys were not conducted if wind speeds were greater than a Beaufort score of three, it was snowing, rainfall was heavy enough to affect hearing ability, or temperatures were below a defined threshold (early season = 5.6°C, mid-season = 12.8°C, late season = 18.3 degrees °C).

<u>Occupancy Modeling</u>

Description

An inherent problem of any animal survey methodology is that species are imperfectly detected (Moilanen 2002). Imperfect detections (false negatives), occurring when a site is assumed unoccupied by a species when in fact it is, can bias inferences regarding that species' habitat utilization and distribution (Tyre et al. 2003). By incorporating a repeated survey study design, occupancy modeling can estimate detection probabilities, thereby providing an unbiased estimate of site occupancy and the coefficients of the site-specific covariates (MacKenzie et al. 2002).

Occupancy models, similar to closed population mark-recapture models, are unique because they distinguish between detection probabilities (p) and occupancy probabilities (Ψ) (MacKenzie et al. 2006). I used the single season occupancy model in Program PRESENCE, an occupancy modeling software package, to estimate p and Ψ of survey sites (Hines 2006). PRESENCE uses repeated survey detection histories, survey-specific detection covariates, and site-specific covariates in a likelihood-based, logistic regression model to estimate p and Ψ, and the relationship of Ψ to the site-specific covariates.

Survey-Specific Detection Covariates

To account for temporal and environmental variability in detection probability, the covariates outlined in Table 2 were used in occupancy models. Measurements of physical features of the landscape or breeding site were not modeled as detection covariates, because they are hypothesized to affect site occupancy. The relationship of the covariates to detection probability is modeled using the logit link function (MacKenzie et al. 2006). In addition to modeling linear terms of these covariates, quadratic and/or pseudo-threshold (LN) relationships were also tested as noted in Table 2. The pseudo-threshold relationship hypothesizes that the real parameter (detection or occupancy probability) changes positively or negatively with each unit increase of a covariate until it approaches an asymptote (Franklin et al. 2000), and is represented by the equation:

$$\text{logit}(\theta) = \beta_0 + \beta_1 \log_e(x_1 + 0.005) + \beta_n \log_e(x_n + 0.005)$$

where θ represents the real parameter (p or Ψ), and x_n represents the covariate of interest. The value of 0.005 was added to covariate values to account for zeroes. The quadratic relationship predicts a maximum effect of the covariate on the real parameter at intermediate values and lesser effects of the covariate at lower and higher values. The quadratic equation is represented by the form:

$$\text{logit}(\theta) = \beta_0 + \beta_1(x_1) + \beta_1(x_1^2) + \beta_n(x_n) + \beta_n(x_n^2)$$

where θ represents the real parameter, and x_n represents the covariate of interest.

Site-Specific Covariates

For each species, I evaluated the relationship of site occupancy to covariates at three life-history spatial scales hypothesized to be important to three different life history stages of Anurans: breeding life-history scale, migration life-history scale, and dispersal life-history scale. All site-specific covariates, their data-types, and sources are outlined in Table 3. All raster data used are at a 30 m cell size resolution. Hand digitized covariates were developed using aerial imagery from the Virginia Base Mapping Program (2009).

Breeding Life-history Scale

The species modeled in my study are all pond-breeding Anurans, possessing bi-phasic life cycles between terrestrial and aquatic environments. Therefore, I hypothesized that occupancy will relate to the amount of available breeding habitat at each of my survey sites. Many ponds and wetlands were surveyed from roads (92%) as access to private lands is notoriously difficult to obtain (Leu pers. comm.). Because of the prevailing access issue, I used aerial photography to quantify breeding habitat covariates (Table 3).

Since the detectability of a species is limited by the distance a surveyor can detect a species (Buckland et al. 2008), the relationship of breeding habitat to site occupancy can only be inferred from habitat which was directly sampled. I determined from field observations that 200 m was the maximum detection distance of calling Anurans and buffered survey sites by 200 m to delineate my area surveyed. Within the 200 m buffer, I calculated four breeding life-history scale covariates: 1) total pond/wetland area (aerial imagery; AREA), 2) pond/wetland perimeter (aerial imagery; PERI), 3) percent canopy cover within a 10 m buffer from the pond/wetland perimeter (hand-digitized from aerial imagery; PERCAN), 4) binary variable, pond (value 0) if pond/wetland was predominantly open water or emergent wetland (value 1) if vegetation dominated (field-based estimates; SITETYPE).

Pond/wetland perimeter is an indirect measure of potential habitat available. I hypothesized that site occupancy was positively related to pond/wetland perimeter assuming that breeding habitat extent correlates with pond/wetland perimeter. Pond/wetland area is also an indirect measure of potential available habitat, but may not correlate with pond/wetland perimeter if a pond/wetland's shape is convoluted. I included both covariates as I hypothesize that for emergent wetlands, area will be a better measure of potential available habitat, while perimeter will be a better measure of available habitat for ponds with open water. I hypothesize that pond area, perimeter, and percent canopy are positively related to site occupancy. The relationship of site occupancy to a survey site's classification as an emergent wetland or pond is expected to vary by species.

Migration Life-history Scale

In pond-breeding Anurans, migration is the movement of individuals from aquatic breeding sites to terrestrial habitats for foraging, summer refugia, and over-wintering (Semlitsch 2008). Based on empirical evidence in the literature, I defined the extent of the migration life-history scale as any buffer extending up to 1 km from a pond/wetland's perimeter (Semlitsch 2008). I hypothesized that the most important predictors to explain heterogeneity in breeding site occupancy are the amount and configuration of available upland land cover (Table 3). To define the extent at which each species was responding to habitat predictors, I evaluated each predictor at 100 m buffer intervals out to 1000 m using a univariate analysis to identify the most important extent for that predictor for a given species.

I developed a percent forest cover (FOR; 42% of total study area) spatial data set by reclassifying Southeast Gap Analysis Project (SE GAP; SE GAP 2010) land cover classes dry, mesic, oak, and pine forest land-cover classes as forest cover. I hypothesized that forest cover is positively related to site occupancy either linearly or as a pseudo-threshold and that degree of forest aggregation is positively related to site occupancy. I measured forest aggregation using the clumpiness index (FORCLUMP) calculated in Fragstats v4, which is a landscape metric that measures the degree of fragmentation of a land cover type in an area without being confounded by the total amount of the land cover in the area (McGarigal et al. 2012). FORCLUMP ranges in values from -1 to 1; a value of 0 equals a random distribution; a value < 0 indicates forest land cover is disaggregated; and a value > 0 is an aggregated distribution of forest land cover. Additionally, an interaction between FOR and FORCLUMP was tested for importance.

Studies have shown that Anurans prefer hydric substrates to avoid desiccation (Tracy et al. 1993) and the moist climates in riparian and wet forests may provide a preferential environment for Anurans relative to dry and mesic forests. However, using land cover of these forest types from the SE GAP was not feasible because of the potential collinearity issues that arise from using percentage data from the same source as the percent forest cover covariate. Therefore I used stream density (STRDEN) as a proxy for riparian and wet forest land cover, which may be a better measure of these micro-habitats that may not be captured in the 30 m resolution of the SE GAP spatial data. Stream density was estimated from the National Hydrography Dataset (U.S. Geological Survey 2005).

Dispersal Life-history Scale

Dispersal in pond-breeding Anurans is the unidirectional or random movement from a natal population to a new breeding population (Semlitsch 2008). While dispersal is poorly understood in Anurans, it is estimated to occur at distances > 1 km (Semlitsch 2008). I therefore defined the dispersal scale as extending between 1 km to 2 km from the pond/wetland perimeter (Smith and Green 2005). I hypothesized that breeding site occupancy relates to availability of potential source habitat and landscape resistance to dispersal (Table 3). Each predictor for this scale was evaluated at 100 m buffer intervals as described previously.

Current literature indicates that many Anuran populations function as metapopulations with significant turnover at breeding ponds/wetlands (Smith and Green 2005). Therefore, I hypothesized that site occupancy will be positively related to the potential for colonization at ponds and wetlands. I used the percent of wetland area (WET) as a measure of potential dispersal land cover as pond-breeding Anurans have been shown to use this land cover as dispersal habitat (Scherer et al. 2012). The wetland area was included as a linear and pseudo-threshold term.

Many vertebrate taxa have been shown to be negatively influenced by roads and their associated traffic volume, either from vehicle related mortalities or an animal's avoidance of roads (Alexander et al. 2005; Koivula and Vermuelen 2005; McCown et al. 2009). I predicted that roads will negatively affect landscape connectivity or the probability of dispersal and therefore will negatively relate to site occupancy. I used two covariates to measure the degree of traffic volume and road density in the landscape. First, I used density of high traffic volume highways (HWY), as this feature is an effective barrier to Anuran dispersal. Interstate and highway densities were based on the U.S. Census Bureau's (2009) spatial data. Second, I used effective mesh size (MESH) as a measure of the degree of road fragmentation in the dispersal life-history scale. Effective mesh size is based on the probability that two random points in an area can be connected without encountering a barrier, a road in my study, and is interpreted as the expected size of a patch in a fragmented landscape when a point in that landscape is randomly chosen (Jaeger 2000; Moser et al. 2007). I hypothesized that effective mesh size relates positively to site occupancy because it is a weighted measure of patch size. The effective mesh size was included as a linear and pseudo-threshold term.

Anthropogenic land cover types including agriculture, urban, suburban, and other human altered land covers are known to impact Anuran connectivity (Verbeylen et al.

2003; Castellon and Sieving 2006; Umetsu et al. 2008). I used National Land Cover Database's (NLCD; Fry et al. 2011) Percent Impervious Surface (IMPERVIOUS) to measure the amount of anthropogenic development in the landscape. I predicted that impervious surface will negatively affect site occupancy thru its effects on dispersal. Impervious surface was included as a linear and pseudo-threshold term.

Modeling and Statistical Analysis Process

Prior to modeling, covariates modeled as quadratic or interaction terms were centered to avoid multicollinearity and all site-specific covariates were standardized to allow for interpretation of effect size across different units of measurement. All survey-specific and site-specific covariates were tested for multicollinearity using Spearman's rank correlation coefficient (Quinn and Keough 2009). Any paired covariates found to have a coefficient value of $> |0.7|$ were not included within the same model. Additionally, the migration and dispersal scale covariates at all 100 m buffer intervals were tested for spatial autocorrelation using Moran's I test (Moran 1950).

All modeling was done in Program PRESENCE (Hines 2006). For each species, occupancy models were used to infer the relative importance of the covariates on site occupancy in four steps. First, I evaluated survey-specific covariates to determine which ones had the greatest effect on detectability while holding the occupancy probability constant across all survey sites. Using the rule of 10 survey sites per parameter estimate (Hosmer and Lemeshow 2000), 11 total parameters for this study (Ψ, p, and 9 covariates), I limited the number of detection covariates to 4 covariates for each model to permit adequate flexibility to model site-specific covariates. The strength of evidence for each model was tested against each other using Akaike's Information Criterion (AIC) (Burnham and Anderson 2008) and the most likely detection covariate model with no more than 4 covariates was selected for each species based on lowest ΔAIC values. The top model was then used to model the site-specific covariates.

Second, I used univariate occupancy models to determine the best scale for each migration and dispersal life-history scale covariates evaluated at 100 m extent intervals (Aldridge et al. 2012). For each covariate, the scale with the top ΔAIC was brought forward to be used in all future models. Third, the relative importance of each covariate was evaluated for each life-history scale. The relative importance of each covariate was determined using measures of cumulative Akaike weights (w_i) within the confidence set of candidate models, 0.1 * (w_i of the top AIC model):

where cumulative w_{ij} at the species level is calculated as:

$$\text{CUM } w_j = (\sum w_{ij})$$

and average cumulative w_{ijk} across all species is calculated as:

$$\text{AVGCUM } w_{jk} = (\text{CUM } w_j)_k \, / \, \text{N}$$

and w_{ijk} is the Akaike weight of the ith candidate model containing the jth covariate of the kth species and N is the total number of species. If all candidate models fall within the confidence set then AVGCUM $w_{ijk} = 1$. All estimates of the coefficients and standard errors reported were model averaged using the w_i from the confidence set of models. Fourth, all covariates represented within the confidence set of candidate life history models were then brought forward and evaluated in a multi-scale model with the same approach being used to evaluate the relative importance of all covariates modeled. As a final step, I ensured model fit using the MacKenzie-Bailey (2004) Goodness of Fit test (100 bootstraps) on the top model in my candidate set of models with the most parameters.

Model performance was assessed using the receiver operating characteristic (ROC) estimating the area under the curve (AUC; Metz 1978). The statistical significance of model performance among life-history scale and the multi-scale model was tested using the Delong test in the statistical software R using the package "pROC" (Delong et al. 1988; Xavier et al. 2011; R Core Development Team 2008).

RESULTS

Survey Sites

Overall, I sampled 56 survey sites in 2011 and 53 survey sites in 2012, however one site was not surveyed in the 2011 mid and late breeding seasons (early breeding season, n = 109; mid and late, n = 108). Mean nearest pond distance was 2.63 km (1.43 SD). Due to the inaccessibility of potential survey sites in rural areas, the distribution of my survey sites across housing density categories is significantly non-uniform (X^2 = 33.06, p = 3.136*e*-07 , df = 3). However my study sites were randomly distributed throughout the study area (observed mean distance = 2.63 km, expected mean distance=2.86km, nearest neighbor ratio = 0.91, p = 0.10). Moran's I tests suggest evidence of spatial autocorrelation in all migration and dispersal life-history covariates and extents except for stream density at 100 and 300 m (E(I) = -0.01; I = 0.02 - 0.39; p = 0.00 - 0.13). The observed spatial autocorrelation is indicative of lack of survey site independence; however, I have accounted for spatial independence by buffering my sites at a biologically relevant scale of ≥ 1 km. The spatial autocorrelation of my sites may indicate an unmeasured variable in the landscape; however, I think the landscape features driving site occupancy have been suitably accounted for. More likely the spatial autocorrelation observed is a result of the unavoidable, non-random distribution of urban environments within my study area.

<u>Species Surveys</u>

I detected 14 of the 20 candidate Anuran species in my study area (Table 1). Five of the detected species had low site occupancy and were not included in analyses because of model overfitting (naïve occupancy <= 0.22). The remaining nine species were found to have adequate fit of their most highly parameterized models by the goodness of fit test (K = 9 - 11, p >= 0.29; Table 1).

I conducted early breeding season surveys from February 15th to April 11th, detecting 3 species sufficiently enough to model (Table 1). For logistical reasons, my surveys extended beyond the NAAMP defined survey end date of March 20th; however all species remained detectable for the duration of my surveys and the survey-specific covariate, Julian date, accounted for any temporal variation in detectability. From my first survey of the mid breeding season, April 27th, to the last survey of the late season, July 17th, I consistently detected six species which were included in my analyses (Table 1). Since each species was modeled individually, and because detections occurred throughout the duration of both breeding seasons, I combined the surveys from the two seasons into one season with a total of six surveys per survey site. Again, any temporal variation in detectability was modeled using Julian date as a covariate. From here forward the combined seasons will be referred to as the late breeding season.

Survey-specific Covariates

Multicollinearity was not present in all survey-specific covariates ($r_s < 0.7$). The most important survey-specific covariate model for all species fit the data better than the constant *p* model (ΔAIC = 6.37 - 77.56). For 6 species the most important survey-specific candidate model had the maximum number of allowed covariates (K = 6), while the spring peeper (*Pseudacris crucifer*) (K = 4), green treefrog (*Hyla cinerea*) (K = 5), and northern cricket frog (*Acris crepitans*) (K = 5) had fewer covariates in their most important model (Appendices 1.a - 9.a). Although models for these species had fewer survey-specific covariates and therefore greater flexibility in modeling site-specific covariates, I maintained a maximum of 5 or fewer site-specific covariates for consistency in interpretation of covariate effects across all species.

Detection probabilities ranged between *p*(0.38) and *p*(0.86) for modeled species (Table 1). Julian date was the most common and important predictor, occurring in the most likely model of 6 species with the quadratic term included in 4 species (Appendices 1.a - 9.a). The survey-specific covariates in the most important candidate model for each species were used in all subsequent analyses.

Site-specific Covariates

The covariates AREA and PERI ($r_s = 0.92$), as well as all buffer interval scales of IMPERVIOUS and MESH ($r_s = -0.86$ to -0.81), were highly correlated and were modeled independently from each other. Percent impervious surface was uncorrelated with smaller scales of FOR (100-200 m; $r_s < 0.70$), but was correlated with larger scales (300 - 1000 m; $r_s = -0.71$ to -0.86). The most important FOR scale for the green treefrog and American bullfrog (*Lithobates catesbeianus*) was 200 m and was modeled in conjunction with IMPERVIOUS in the multi-scale life history model; for all other species, the two covariates were modeled independently of each other. Percent forest cover was uncorrelated with MESH at scales less than 500 m ($r_s < 0.70$), but was correlated with effective mesh size at larger scales (e.g. FOR 500m and MESH 1700 - 2000m; $r_s = 0.70$; FOR 1000m and MESH 1300 - 2000m; $r_s = 0.70 – 0.74$). I modeled FOR and MESH independently for six species (pickerel frog [*Lithobates palustris*], southern leopard frog [*Lithobates sphenocephalus*], spring peeper, Cope's gray treefrog [*Hyla chrysoscelis*], green frog [*Lithobates clamitans*], and northern cricket frog), but included both covariates in three species models (American bullfrog, Fowler's toad [*Anaxyrus fowleri*], and green treefrog) because they were uncorrelated at smaller scales.

Breeding Life-history Scale

The relative effects of the site-specific covariates at the breeding life-history scale varied by species and there was no strong support for any one covariate for all species (Figures 3.a - i; Figure 7.a; Appendices 1.j - 9.j). In the case of the southern leopard frog and Fowler's toad there was weak support for any covariate as the constant occupancy model (no covariates) was the second ranked model and within $\Delta AIC = 2$. Percent canopy cover and SITETYPE occurred most frequently among all species in the most important breeding life-history scale model and had the highest average cumulative w_{jk}

(AVGCUM w_{jk}), 0.54 and 0.47 respectively (Figure 7.a). The AVGCUM w_{jk} for AREA was 0.40 and 0.30 for PERI.

Percent canopy cover was included in the most important models of the green frog, northern cricket frog, pickerel frog, and spring peeper, but had coefficient estimates equal to no effect for the Cope's gray treefrog, Fowler's toad, green treefrog, and southern leopard frog (Figures 3.a-i ; Appendices 1.j - 9.j). The relative importance of PERCAN to occupancy probability was high for the spring peeper (CUM $w_j = 0.8$), northern cricket frog (CUM $w_j = 0.93$), and green frog (CUM $w_j = 1.00$). For the green frog, the coefficient of PERCAN (0.83 [0.26]) was an order of magnitude larger than the other modeled covariates which were estimated to have no effect. The American bullfrog was the only species with a probability of occupancy negatively related to PERCAN.

The binary classification of survey sites, SITETYPE, occurred in the most important model of 4 species, the American bullfrog, Cope's gray treefrog, southern leopard frog, and spring peeper, however, the effect of SITETYPE for the other 5 species was no different from zero effect (Figures 3.a - i ; Appendices 1.j - 9.j). The classification of a study site as an emergent wetland (positive relationship to occupancy probability), was the only covariate to have an effect on southern leopard frogs and was in the most likely model, but had weak support when compared to the constant occupancy model ($\Delta AIC = 0.33$). The probability of occupancy of the spring peeper and Cope's gray treefrog was also positively related to SITETYPE, and was a relatively important predictor of occupancy for the Cope's gray treefrog (CUM $w_j = 0.86$). American bullfrog occupancy (CUM w_j = 0.87) was negatively related to SITETYPE, suggesting an important affinity to sites with open water.

As stated, pond/wetland area and perimeter were highly correlated and this relationship was observed in the similar CUM w_j values of the covariates for the American bullfrog, green frog, pickerel frog, southern leopard frog, and spring peeper (CUM_{AREA} w_j - CUM_{PERI} w_j = 0.01 - 0.15; Figures 3.a - i; Appendices 1.j - 9.j). Pond/wetland area was an important predictor of site occupancy for the Cope's gray treefrog (CUM w_j = 0.55) and green treefrog (CUM w_j = 1.00), which had an estimated coefficient (2.77 [0.98]) orders of magnitude larger than the other modeled covariates which were equivalent to no effect. Pond/wetland perimeter was in the most important model for the northern cricket frog (CUM w_j = 0.55) and the Fowler's toad, but was weakly supported compared to the second ranked constant occupancy model (ΔAIC = 0.52). The estimated coefficient of PERI for 6 species was equal to no effect. Pond/wetland area and perimeter had relatively equal importance in explaining variation in pickerel frog occupancy (CUM_{AREA} w_j = 0.48; CUM_{PERI} w_j = 0.52), but the effect size of AREA (1.45 [0.53]) was relatively greater than PERI (0.66 [0.20]).

Migration Life-history Scale

Model selection results of covariate spatial scale varied by species and covariate (mean = 718 m [317]; Figure 2). Percent forest cover (mean = 767 m [300]) was found to be most important at larger scales for 66.7% of species (800 - 1000 m; Appendices 1.b - 9.b). Like FOR, most species responded to FORCLUMP (mean = 822 m [295]) at large scales (700 - 1000 m; n = 7 species; Appendices 1.c - 9.c). The spatial scale of the relationship of STRDEN to occupancy probability was more variable among species, ranging between100 - 1000 m (mean = 567 m [347]; Appendices 1.e - 9.e).

The pseudo-threshold relationship better fit the relationship between FOR and occupancy probability for the pickerel frog, southern leopard frog, spring peeper, Cope's gray treefrog, and Fowler's toad (Appendices 1.b - 9.b). The interaction term for FOR and FORCLUMP had little support for any species and was never selected as the most important model (Appendices 1.d - 9.d). Although the interaction term for the green treefrog was not important, the scale of the most important model of this analysis, Ψ(FORLN200, FORCLUMP200), was different from the one selected in the univariate analysis, Ψ(FORLN1000, FORCLUMP1000) (ΔAIC = 2.27). Unsure how to interpret these results, and because model averaging across spatial scales is illogical, I chose to test the effects of all four covariates in the migration scale and the multi-scale life history model, but only testing FORLN200 and FORCLUMP200 in combination, while allowing FORLN1000 and FORCLUMP1000 to be modeled separately or combined.

For all species, FOR was included in the most likely life-history model and was the overall most important predictor of species occupancy probability at the migration life-history scale (AVGCUM w_{jk} = 0.77; Figure 7.b; Appendices 1.k - 9.k). Percent forest cover was the most important predictor for the pickerel frog, spring peeper, Cope's gray treefrog, green frog, and northern cricket frog, which was reflected in the relative effect size of the estimated coefficients (1.10 - 1.68 [0.29 - 0.45]; Figures 4.a - i). The effect of FOR was consistently positive except in the case of the American bullfrog (-0.40 [0.21]).

There was weak support for the most likely model because the constant occupancy model was found to have relatively high importance (ΔAIC = 1.37).

The forest clumpiness index was the least important predictor of species occupancy probability (AVGCUM w_{jk} = 0.55; Figure 7.b; Appendices 1.k - 9.k). Only the Fowler's Toad had FORCLUMP as its most important predictor (CUM w_j = 0.94), although it was also included as a weak predictor in the most important models of the pickerel frog, spring peeper, and green frog. The effect of FORCLUMP was consistently positive for all species.

Stream density was in the most important model of all species except for the spring peeper, Cope's gray treefrog, and Fowler's toad (AVGCUM w_{jk} = 0.60; Figure 7.b; Appendices 1.k - 9.k). The effect of STRDEN was most important for the American bullfrog, green treefrog, and southern leopard frog. The relationship of STRDEN to occupancy was negative for the American bullfrog and southern leopard.

Dispersal Life-history Scale

The most important spatial scale for the dispersal life-history scale covariates varied by species and covariate (mean = 1664 m [347]; Figure 2). Highway density was most important at 2000 m for all species except for the American bullfrog (1400 m) and southern leopard frog (1200 m; Appendices 1.h - 9.h). The most important spatial scale was also highly variable for IMPERVIOUS (mean = 1633 m [374]; Appendices 1.f - 9.f), MESH (mean = 1589 m [355]; Appendices 1.g - 9.g) , and WET (mean = 1589 m [344]; Appendices 1.i - 9.i), however the mode for all three covariate scales was 2000 m.

The pseudo-threshold relationship was more important than the linear term for 5 species for each of the 3 covariates; IMPERVIOUS (Appendices 1.f - 9.f): pickerel frog, spring peeper, green treefrog, green frog, and northern cricket frog; MESH (Appendices 1.g - 9.g): southern leopard frog, American bullfrog, Cope's gray treefrog, Fowler's toad, and northern cricket frog; and WET (Appendices 1.i - 9.i): spring peeper, American bullfrog ,Cope's gray treefrog, Fowler's toad, and northern cricket frog.

Percent impervious surface (n = 5 species; AVGCUM w_{jk} = 0.61) and MESH (n = 4 species; AVGCUM w_{jk} = 0.37) were the most important predictors of occupancy probability at the dispersal life-history scale (Figures 5.a-i; Figure 7.c; Appendices 1.l - 9.l). Although an important predictor for some species, the AVGCUM w_{jk} value for MESH was the lowest of all modeled covariates. The low AVGCUM w_{jk} of MESH is explained by its correlation with IMPERVIOUS, because it was completely absent from the confidence set of 4 species where IMPERVIOUS was most important. Highway density (AVGCUM w_{jk} = 0.52) and WET (AVGCUM w_{jk} = 0.45) were moderately important in predicting occupancy for some species.

In the species models where IMPERVIOUS was most important (pickerel frog, southern leopard frog, Cope's gray treefrog, green treefrog, and northern cricket frog), the effect was consistently large and negative (-0.71 to -2.20 [0.22 - 0.73]). Only the American bullfrog had a positive, albeit weak relationship to IMPERVIOUS (0.18 [0.12]). Three species (spring peeper, Fowler's toad, and green frog), had relatively strong positive relationships with MESH (0.52 - 3.04) [0.19 - 0.85]). Effective mesh size had a relatively strong negative effect on American bullfrog occupancy. Highway density was in the most likely model for 4 species, having a negative effect on northern cricket frog occupancy, and interestingly, a positive effect on pickerel frog, southern leopard frog and green frog occupancy. The most important models for the southern leopard frog and northern cricket frog included WET as a covariate in a positive and negative relationship, respectively. Percent wetland cover had no effect on any other species.

Multi-scale Life-History Model

When all life-history scale covariates were modeled together, FORCLUMP was the overall most important predictor of species occupancy (AVGCUM $w_{jk} = 0.67$; Figures 6.a - i; Figure 7.d; Appendices 1.m - 9.m). The forest clumpiness index was in the most important model of 5 species, had the greatest relative effect on the Cope's gray treefrog (1.46 [0.45]), moderate relative effects on the pickerel frog, green treefrog, green frog, and northern cricket frog (0.93 - 1.18 [0.38 - 0.41]), and no effect on the southern leopard frog and American bullfrog. The most important covariates representative of the other two life-history scales were SITETYPE (AVGCUM $w_{jk} = 0.37$) and HWY (AVGCUM $w_{jk} = 0.45$), however, these results may be misleading because of the exclusion of correlated covariates. An examination of the relative effects of HWY only shows a strong relative effect on northern cricket frog occupancy (-1.27 [0.42]), while the dispersal scale covariate of MESH had strong relative effects on three species (0.87 - 1.88 [0.39 - 0.79]), but was almost completely excluded from the candidate model confidence set of three species. The covariate with the greatest relative effect in each species' multi-scale model varied by life-history scale and covariate although the greatest proportion of covariates were represented at the migration and dispersal scales (n = 4 species).

Model Performance

Model performance of the life-history and multi-scale models varied significantly in their efficacy of predicting the observed site occupancy, the southern leopard frog and American bullfrog had no statistically significant differences in model performance and will be excluded from the remaining summary. The multi-scale model (AUC_{MULTI} = 0.71 - 0.92) was the overall best predictor of observed occupancy for all species, except for the green treefrog dispersal scale, although observed differences in model performance for the green treefrog were non-significant (AUC_{DISP} = 0.78, AUC_{MULTI} = 0.72, p = 0.07). All three life-history scales for the spring peeper, green frog, and northern cricket frog, or both the breeding and migration scales for pickerel frog and Cope's gray treefrog, were significantly outperformed by the multi-scale model. The sensitivity of the breeding scale model was poor to fair (AUC_{BREED} = 0.60-0.75) and was a significantly worse predictor of observed site occupancy than the multi-scale model (p = 0.00 - 0.01) in six species. The migration scale (AUC_{MIGR} = 0.70 - 0.86) significantly outperformed the breeding scale in 5 species (p = 0.00 - 0.05); did not differ from the dispersal scale (AUC_{DISP} = 0.64 - 0.87) at all; and was outperformed by the multi-scale model in 5 species (p = 0.01 - 0.05). The observed occupancy of six species was significantly better predicted by the dispersal model than the breeding model (p = 0.00 - 0.02).

DISCUSSION

In this study, I found that pond/wetland occupancy by pond-breeding Anurans was dependent on variables at multiple spatial scales relevant to their life-history stages and that a multi-scale analysis was often the best method for explaining variation in occupancy. The smallest, breeding life-history scale was a poor to fair (AUC = 0.60 - 0.75) predictor of occupancy and was significantly worse or no better than the migration and dispersal scales at explaining patterns of Anuran site occupancy. The observed poor performance of the breeding scale is supported by other recent studies that have found amphibian distributions to be more strongly related to landscape-scale variables than variables at local scales (Pope et al. 2000; Mazerolle et al. 2005; Scherer et al. 2012). Models for the migration life-history scale were fair to good (AUC = 0.70 - 0.84) and had no observed difference when compared to the dispersal life-history scale models, which had poor to good model performance (AUC = 0.64 - 0.74). The lack of difference in the migration and dispersal scales suggests that both scales are equally important drivers of site occupancy by Anurans. The multi-scale model was a fair to excellent (AUC = 0.71 - 0.92) predictor of site occupancy and had significantly better performance than one or more life-history scale models in 7 species. The better performance of the multi-scale model across species highlights that limiting conservation actions to one spatial scale can be detrimental to species persistence and that effective planning requires consideration of all scales of a species life-history.

Anurans require aquatic habitats for both breeding and larval development and studies have found variables important for site occupancy to include pond/wetland size (Bradford et al. 2003), water chemistry (Hamer and Parris 2010), vegetation structure (Mazzerole et al. 2005), and predator density (Van Buskirk 2005). Due to the inaccessibility of many of my survey sites, inclusion of breeding life-history scale covariates were limited to coarse measurements in a GIS, such as percent canopy cover derived from aerial photography. Despite the coarse resolution of these covariates, I did observe relatively strong effects for all of the selected breeding life-history scale covariates. Percent canopy cover can be interpreted as a proxy for shoreline vegetation structure and it had a strong positive effect on spring peeper and green frog site occupancy; however, in the multi-scale model this effect diminished for the spring peeper, suggesting that covariates at larger landscape scales are more important to explaining heterogeneity in pond/wetland occupancy than percent canopy cover. The American bullfrog and Cope's gray treefrog had a strong relationship to whether or not a site was classified as a pond or wetland, with the bullfrog preferring pond habitats and the treefrog preferring wetlands. Because pond/wetland area and perimeter strongly correlate, this would imply that they are expressing the same habitat characteristic and therefore should have similar effects on species; however, not all species related equally to these covariates suggesting an underlying difference of biological importance between the two variables. Pond/wetland area had a strong positive effect on the pickerel frog, Cope's gray treefrog, and green treefrog occupancy and a relatively moderate positive effect on American bullfrog occupancy. The pickerel frog also had a relatively moderate relationship to pond/wetland perimeter. In the multi-scale model the relative effects of these covariates changed with area diminishing to nearly no effect on the Cope's gray treefrog occupancy and emerging as having a strong effect for the American Bullfrog. In the case of the pickerel frog, perimeter emerged to have a strong effect while the effect of area diminished by almost an order of magnitude. Although correlated, the difference in effect of perimeter and area highlights the need for careful consideration when choosing model covariates. If covariate variables were omitted because of collinearity, as often is the case in model building, information important to the system of interest may be lost (Zuur 2010). Additionally, the observed changes in effect of area and perimeter from the breeding scale model to the multi-scale model illustrate the importance of scale and how conclusions made at one scale can misconstrue the underlying processes of a system (Ruggiero et al. 1994). While my results indicate that the breeding scale alone is an inadequate unit of conservation or study, the covariates at this scale are still important drivers of species distributions and must be considered to avoid spurious effects.

Anurans utilize the terrestrial environment surrounding aquatic habitats for foraging, summer refugia, and overwintering, and disperse through the terrestrial landscape to colonize other aquatic habitats. Scaling up from the aquatic to the terrestrial environment reveals the emergent landscape level properties of composition and configuration. Studies have shown that the drivers of these properties such as forest cover (Mazerolle et al. 2005) and distance to wetlands (Scherer et al. 2012) relate positively, while urbanization (Rubbo and Kiesecker 2005) and roads or traffic (Eigenbrod et al. 2008) relate negatively to patterns of Anuran distributions. However, these studies have only examined the drivers of landscape composition and configuration at one scale or independently at multiple scales. To my knowledge, this is the first study to simultaneously examine these drivers at multiple scales relevant to the life-history stages of dispersal and migration.

The migration life-history scale covariates measuring landscape forest composition and configuration were important predictors of site occupancy in many species, while stream density only had strong effects on the southern leopard frog. Percent forest cover was the strongest positive predictor of Anuran site occupancy for most species (n = 6 species), however in the multi-scale model, the relative effect of percent forest cover was greatly diminished in 4 species, in 2 cases by an order of magnitude. In three species, the decrease in importance of percent forest cover in the multi-scale model was mostly likely a result of the exclusion of correlated covariates, where either effective mesh size or percent impervious surface was an important predictor of site occupancy. Although correlated, the effect of these covariates are interpreted differently; percent forest cover represents the amount of available habitat in the landscape, effective mesh size measures road fragmentation or access to available habitat, and percent impervious surface represents habitat loss (a direct correlation with percent forest cover in a binary landscape), but also access to available habitat. The most important 100 m buffer interval scale for percent forest varied by species. In four species, three of which responded strongly to percent forest cover, I found the maximum limit for the migration life-history scale, 1000 m, to be the most important scale. Model selection of percent forest cover at the 1000 m scale suggests that the importance of percent forest cover may extend beyond the defined extent of the migration life-history scale. In the multi-scale model, the effect of percent forest cover modeled at the 1000 m buffer interval scale was greatly reduced in 2 species, while the correlated covariates of either percent impervious surface or effective mesh size had relative strong effects on site occupancy. The relative importance of percent forest cover at the 1000 m buffer interval can be interpreted in two different ways; for these species the scale of migration is larger than that suggested by the literature (Semlitsch 2008) or percent forest cover is an important variable in the dispersal life-history scale. However, since percent forest cover is correlated with percent impervious surface and effective mesh and because the analysis of percent forest cover was limited to 1000 m, my data lacks the capability for further inference. Further investigations of migration and dispersal distances as well as the role of percent forest cover in these species are warranted.

The forest clumpiness index had relatively strong to moderate positive (forest aggregation) effects for 3 species in the migration life-history scale model and emerged as the most important predictor of occupancy probability in the multi-scale model with an AVGCUM w_{jk} value of 0.76. However, these results in the multi-scale model are confounding because the forest clumpiness index only had a strong effect on 4 species and was the most important predictor in only one species model. In comparison, percent forest cover, effective mesh size, and percent impervious surface had strong effects on more species and/or were the most important predictor in species models. Most likely, these results are influenced by bias incurred in AVGCUM w_{jk} when two correlated covariates are included in an analysis and modeled independently. In these analyses uncorrelated covariates receive greater representation across the entire set of candidate models. Although the forest clumpiness index and percent forest cover were important predictors of site occupancy, the interaction of the two covariates was relatively unimportant and not included in the final set of candidate models. A potentially better metric of forest composition and configuration in the landscape would be the *percentage of like adjacencies* (PLADJ; McGarigal et al. 2012) which is a measure both landscape properties; however, the interpretation of the effects of the two properties in PLADJ can be difficult. My findings provide strong evidence for the importance of forest composition and configuration in the landscape surrounding ponds/wetlands to Anuran site occupancy and contribute to the argument for the inclusion of habitat buffers in wetland conservation (Semlitsch 2003).

Many Anuran populations are believed to function as metapopulations and dispersal is critical for recolonization after local populations go extinct (Smith and Green 2005). The process of Anuran dispersal is poorly understood (Semlitsch 2008); however it has been found that site occupancy is negatively related to urbanization (Rubbo and Kiesecker 2005), roads (Eigenbrod et al. 2008), and increasing distance to neighboring wetlands (Scherer et al. 2012), suggesting that landscape connectivity plays a large role in the relative success of dispersal events. In almost all cases, the most important 100 m buffer interval for dispersal life-history scale covariates was greater than the defined minimum limit of 1100 m, suggesting that these covariates are acting at scales relevant to Anuran dispersal. In the dispersal life-history scale model there were strong relative effects of percent impervious surface at 1100 m in the northern cricket frog and the effective mesh size at 1100 m in the Fowler's toad; however, these relationships were negligible in the multi-scale model. These observations could imply a mismatch of scales for these covariates or that the scale of dispersal is smaller than expected for these species. It could be that Fowler's toads do have smaller scales of dispersal since none of the dispersal scale covariates had a strong effect on their site occupancy. However, the evidence suggests that the northern cricket frog does disperse within my defined scale of dispersal, as it is strongly affected by percent wetland cover and highways at 1500 and 2000 m, respectively. As was the case with the migration scale covariates, many of the dispersal life-history scale covariates were found to be important at the maximum 100 m buffer interval (2000 m) suggesting that dispersal may be occurring at scales larger than those defined by my study.

The correlated covariates, effective mesh size and percent impervious surface, were the most important predictors of Anuran occupancy in the dispersal life-history scale model, implying that roads and development disrupt landscape connectivity. In the multi-scale model the relative magnitude of effect among dispersal scale covariates remained unchanged except in the cases of the Fowler's toad and northern cricket frog. Fowler's toad occupancy was strongly affected by percent impervious surface in the dispersal scale model, but in the multi-scale model the percent impervious surface had no effect and highway density emerged as a moderately important predictor. Percent impervious surface was also the most important predictor of northern cricket frog occupancy at the dispersal scale with highway density and percent wetland cover having moderate effects. In the multi-scale model the relative effect sizes of the covariates switched and highway density emerged as most important overall predictor among all covariates, while percent wetland cover had relatively strong effects, and percent impervious surface had relatively low effects on northern cricket frog occupancy. The observed switches in effect size of covariates from the dispersal scale to the multi-scale model again illustrates how spurious effects can arise from mismatching scales and underpins the necessity of multi-scale approaches in ecology.

The importance of the role of scale in conservation and ecological studies has been recognized in the literature for decades (Levin 1992, Sandel and Smith 2009). Wiens (1989) described 'scale' as becoming the new ecological buzzword. While frequently discussed, the application of scale and more specifically multi-scale approaches in ecology remains relatively uncommon. A recent review of high impact journals published in 2007 found only 7% of articles containing the term 'spatial scale' and only half of those studies implemented a multi-scale approach (Sandel and Smith 2009). The scale of investigation on a system can have profound and confounding effects on inferences and highlights the need for multi-scale approaches in ecology (Ruggerio et al. 1994). My study demonstrates that the role of scale is important in predicting occupancy for pond-breeding Anurans and suggests that a multi-scale approach encompassing a species entire life-history is necessary to accurately predict occupancy.

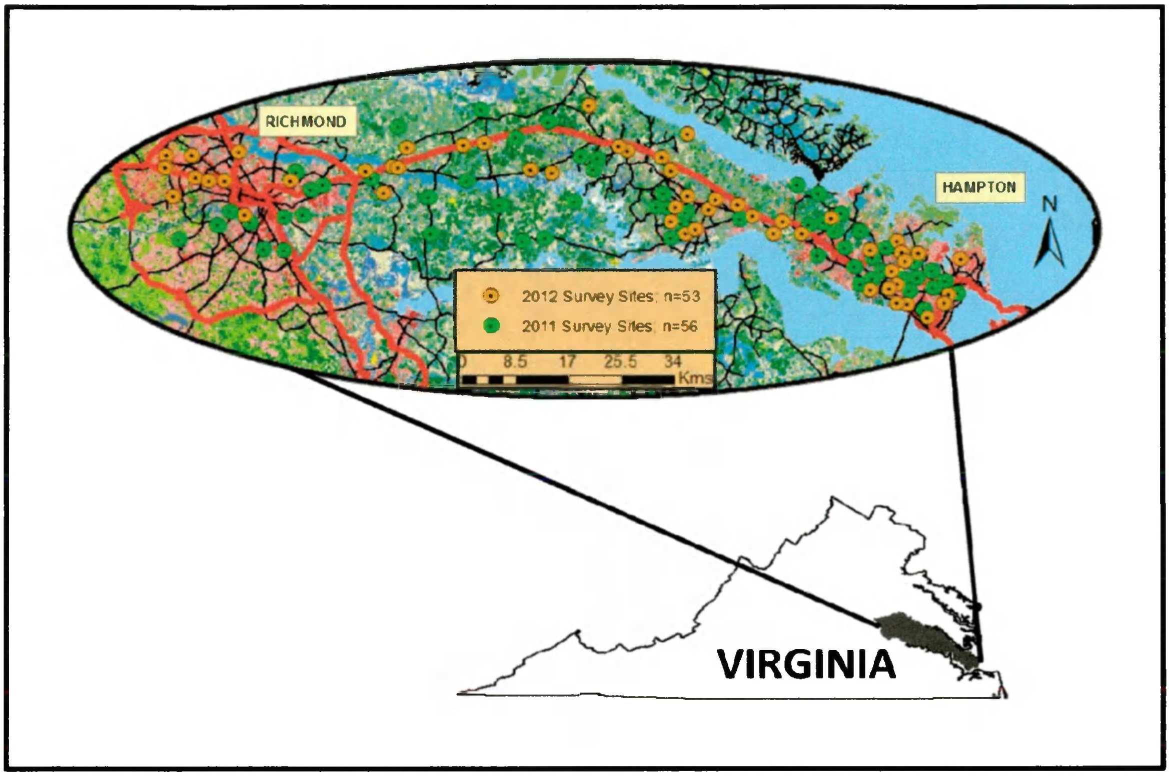


Figure 1: Map of the study area in eastern Virginia (3578 km^2).

	SPECIES	NAÏVE OCCUPANY	PROBABILITY OF DETECTION	GOODNESS OF FIT
EARLY SEASON	American Toad (*Anaxyrus americanus*)	0.22	0.36 (0.22-0.52)	NA
	Brimley's Chorus Frog (*Pseudacris brimleyi*)	NA	NA	NA
	Pickerel Frog (*Lithobates palustris*)*	0.47	0.51 (0.42-0.61)	p=0.90
	Southern Toad (*Anaxyrus terrestris*)	NA	NA	NA
	Southern Leopard Frog (*Lithobates sphenocephalus*)*	0.61	0.66 (0.58-0.73)	p=0.29
	Spring Peeper (*Pseudacris crucifer*)*	0.58	0.86 (0.80-0.90)	p=0.83
	Upland Chorus Frog (*Pseudacris feriarum*)	0.06	0.63 (0.39-0.83)	NA
MID AND LATE SEASON	American Bullfrog (*Lithobates catesbeianus*)*	0.92	0.71 (0.97-0.74)	p=0.48
	Barking Treefrog (*Hyla gratiosa*)	NA	NA	NA
	Cope's Gray Treefrog (*Hyla chrysoscelis*)*	0.60	0.47 (0.42-0.52)	p=0.75
	Eastern Spadefoot Toad (*Scaphiopus holbrookii*)	NA	NA	NA
	Fowler's Toad (*Anaxyrus fowleri*)*	0.54	0.38 (0.33-0.44)	p=0.71
	Eastern Narrow-mouth Toad (*Gastrophryne carolinensis*)	0.14	0.07 (0.02-0.20)	NA
	Gray Treefrog (*Hyla versicolor*)	NA	NA	NA
	Green Frog (*Lithobates clamitans*)*	0.79	0.74 (0.70-0.78)	p=0.83
	Green Treefrog (*Hyla cinerea*)*	0.49	0.56 (0.50-0.61)	p=0.43
	Northern Cricket Frog (*Acris crepitans*)*	0.39	0.74 (0.68-0.79)	p=0.65
	Pine Woods Treefrog (*Hyla femoralis*)	NA	NA	NA
	Southern Cricket Frog (*Acris gryllus*)	0.12	0.50 (0.38-0.62)	NA
	Squirrel Treefrog (*Hyla squirella*)	0.02	0.003 (0.001-0.012)	NA

Table 1: Candidate species in study area. * denotes modeled species. Naïve occupancy is the number of sites where a species was detected divided by the number of sites surveyed. Detection probability is the constant probability across all surveys and sites without the modeled influence of survey-specific covariates. Goodness of fit reports the probability that the observed data's test statistic (X^2) is a random outcome of the distribution of test statistics of bootstrapped fitted models.

METRIC (PREDICTED RELATIONSHIP)	UNITS	DESCRIPTION
Background Noise Index (-)	Categorical	0 = No appreciable effect (e.g., owl calling), 1 = Slightly affecting sampling (e.g., distant traffic, dog barking, 1 car passing), 2 = Moderately affecting sampling (e.g., nearby traffic, 2-5 cars passing), 3 = Seriously affecting sampling (e.g., continuous traffic nearby, 6-10 cars), 4 = Profoundly affecting sampling (e.g., continuous traffic passing, construction).
Beaufort Wind Score (-)	Categorical	0= Calm (< 1 mph; smoke rises vertically), 1= Light air (1-3 mph; smoke drifts, weather vane inactive), 2= Light breeze (4-7 mph; leaves rustle, can feel wind on face), 3= Gentle breeze (8-12 mph; leaves and twigs move around, small flag extends), 4= Moderate breeze (13-18 mph; moves thin branches, raises loose paper), Surveys are not conducted at Beaufort 4.
Days Since Rain* (-)	Number of Days	N/A
Days Since Above Average Rain of Survey Period* (-)	Number of Days	Average rainfall is calculated using daily precipitation totals from the nearest airport with a weather station to the survey site and ranging from the first day surveyed to the last of a survey period.
Sky and Weather Condition (-)	Categorical	0 = Few clouds, 1 = Partly cloudy (scattered) or variable sky, 2 = Cloudy or overcast, 3 = Fog or smoke, 4 = Drizzle or light rain (does not affect hearing ability), 5 = Snow, 6 = Showers.
Time of Day^{+}* (-)	Hours	Measured from a fixed time and from time since sunset.
Julian Date^{+} (+)	Number of Days	Measured from the first day of the survey season. Adjusted to a bi-weekly scale.
Temperature (+)	Degrees Celsius	Adjusted to a two degree per unit scale.
Wind Speed (+)	Meters per Second	N/A

Table 2: Survey-specific detection covariates with their predicted relationship (+/-) to detection probability. Survey-specific detection covariates were selected from the NAAMP protocol (Weir and Mossman 2005). The number of observations for noise index category four was sparse (early=17/327; late=23/648) and was combined with category three. There were no observation for sky and weather categories 3, 5, and 6 and were omitted from models. The number of observations for sky and weather category four was sparse (early=9/327; late=3/648) and was combined with category two. $^{+}$Denotes a quadratic relationship was also tested for this covariate. *Denotes a pseudo-threshold relationship was also tested for this covariate.

	METRIC (PREDICTED RELATIONSHIP)	UNITS	DATA TYPE	DATA SOURCE
BREEDING	Percent Canopy (+)	Percent Area	Vector	Hand Digitized
	Site Area* (+)	Hectares	Vector	Hand Digitized
	Site Perimeter (+)	Hectometers	Vector	Hand Digitized
	Site Type	Wetland/Pond	N/A	N/A
MIGRATION	Percent Forest Cover* (+)	Percent Area	Raster	(SE GAP 2010)
	Forest Clumpiness Index (+)	N/A	Raster	(McGarigal et al. 2012)
	Stream Density (+)	Km/Km^2	Vector	(U.S. Geological Survey 2005)
DISPERSAL	Percent NLCD Impervious Surface* (-)	Percent Area	Raster	(Fry et al. 2011)
	Effective Mesh Size (Road Fragmentation)* (+)	Hectares	Raster	(McGarigal et al. 2012)
	Highway Density* (-)	Km/Km^2	Vector	(Tiger/line shapefiles 2010)
	Percent Wetland Cover (+)	Percent Area	Vector	(Cowardin et al. 1979)

Table 3: Site-specific covariates with their predicted relationship (+/-) to occupancy probability. *Denotes a pseudo-threshold relationship was also tested for this covariate.

	Species	Intercept	Background Noise Index			Beaufort Wind Score			Days Since Rain	Days Since Above Average Rain
			1	2	3 and 4	1	2	3		
EARLY	Pickerel Frog	-0.13 (0.65)	X	X	X	X	X	X	X	X
	Southern Leopard Frog	1.56 (0.55)	-1.53 (0.61)	-1.80 (0.63)	-2.89 (0.73)	X	X	X	0.43 (0.14)	X
	Spring Peeper	-0.42 (0.73)	X	X	X	X	X	X	-0.31 (0.11)*	X
MID AND LATE	American Bullfrog	1.20 (0.21)	X	X	X	X	X	X	X	-0.06 (0.03)
	Cope's Gray Treefrog	-4.00 (1.01)	X	X	X	X	X	X	X	X
	Fowler's Toad	-6.84 (1.34)	X	X	X	X	X	X	-0.34 (0.08)	X
	Green Frog	2.16 (0.28)	-1.06 (0.29)	-1.46(0.33)	-1.15 (0.39)	X	X	X	X	-0.05 (0.03)
	Green Treefrog	-2.81 (1.04)	X	X	X	X	X	X	X	X
	Northern Cricket Frog	1.04 (0.19)	X	X	X	X	X	X	X	X

	Species	Julian Date	Julian Date Quadratic	Sky and Weather Condition		Temperature	Time of Day	Time Since Sunset	Wind Speed
				1	2-4				
EARLY	Pickerel Frog	0.31 (0.12)	-0.25 (0.07)	X	X	0.18 (0.08)	X	X	-1.06 (0.31)
	Southern Leopard Frog	X	X	X	X	X	X	X	X
	Spring Peeper	X	X	X	X	0.29 (0.11)	X	X	X
MID AND LATE	American Bullfrog	-0.07 (0.03)	-0.03 (0.01)	X	X	X	X	0.61 (0.14)*	X
	Cope's Gray Treefrog	-0.16 (0.04)	-0.03 (0.01)	X	X	0.34 (0.08)	X	0.43 (0.17)*	X
	Fowler's Toad	-0.38 (0.05)	X	X	X	0.67 (0.12)	X	-0.35 (0.10)	X
	Green Frog	X	X	X	X	X	X	X	X
	Green Treefrog	0.10 (0.04)	-0.05 (0.01)	X	X	0.34 (0.09)	X	X	X
	Northern Cricket Frog	-0.12 (0.05)	X	0.90 (0.48)	0.01 (0.42)	X	X	X	X

Table 4: Coefficients of survey-specific covariates with their standard errors in parentheses from the most important candidate model when occupancy probability is held constant across all sites. *Denotes a pseudo-threshold was the most important relationship for a covariate

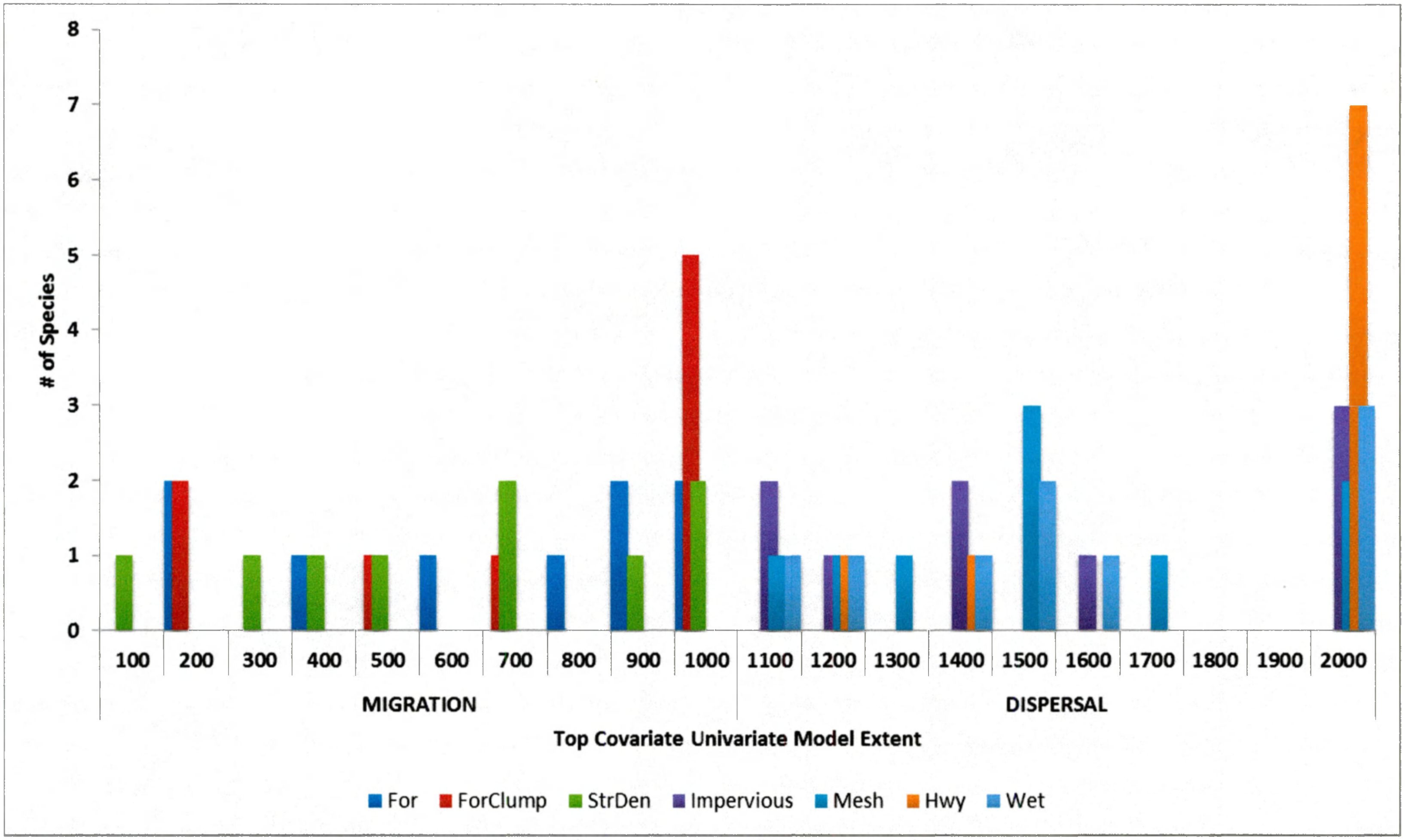


Figure 2 For each species, the most important extent that predicts site occupancy for each site-specific covariate. Covariate names are: Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

Figures 3.a--c The relative effects of each site-specific covariate on occupancy at the breeding life-history scale; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**.

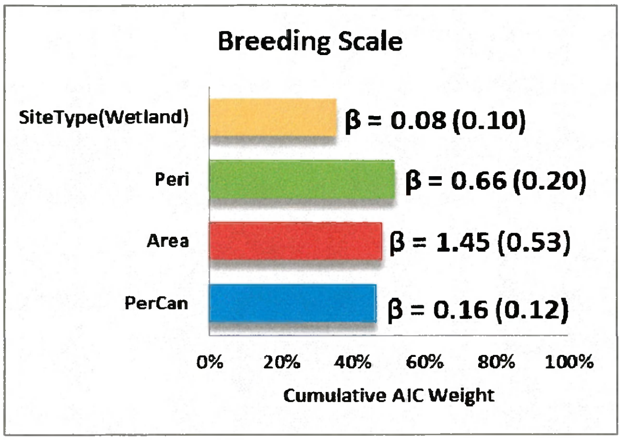


Figure 3.a Pickerel Frog

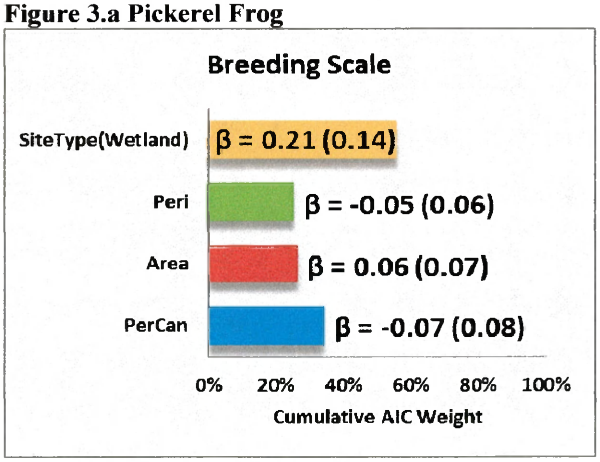


Figure 3.b Southern Leopard Frog

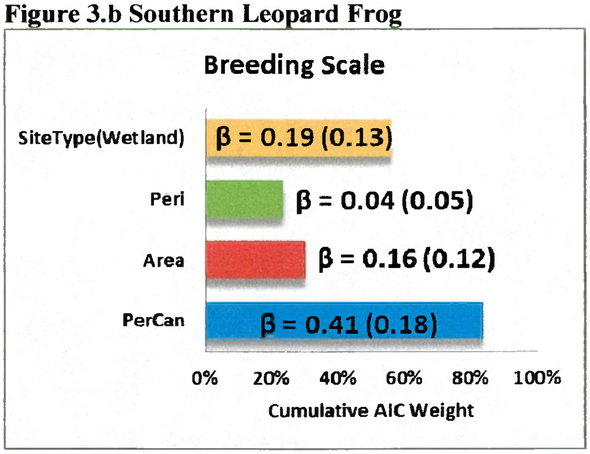


Figure 3.c Spring Peeper

Figures 3.d-f The relative effects of each site-specific covariate on occupancy at the breeding life-history scale; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**.

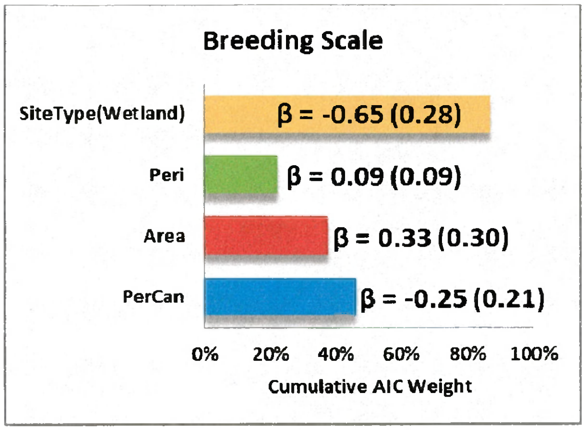


Figure 3.d American Bullfrog

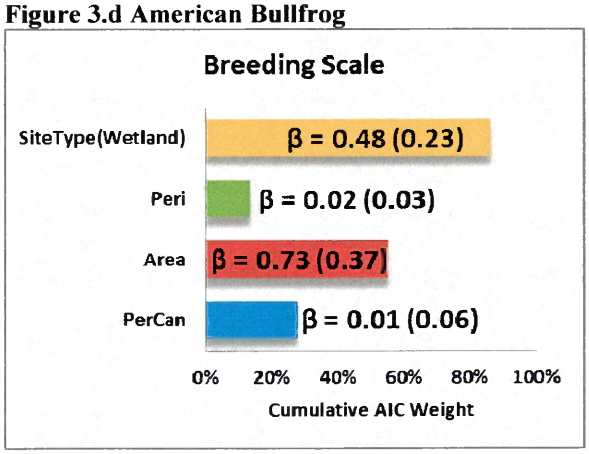


Figure 3.e Cope's Gray Treefrog

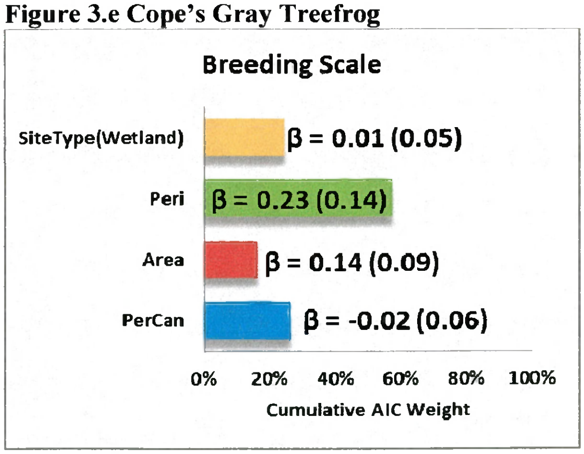


Figure 3.f Fowler's Toad

Figures 3.g-i The relative effects of each site-specific covariate on occupancy at the breeding life-history scale; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**.

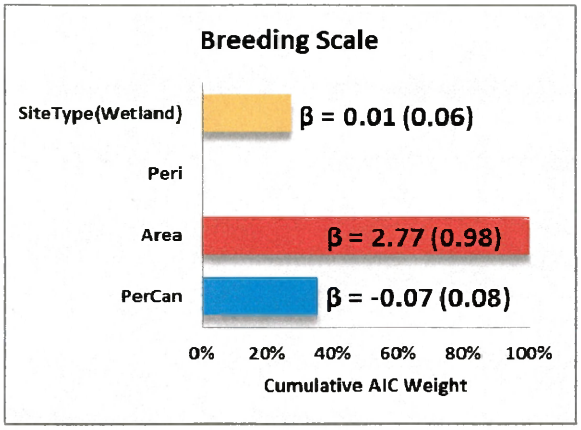


Figure 3.g Green Treeforg

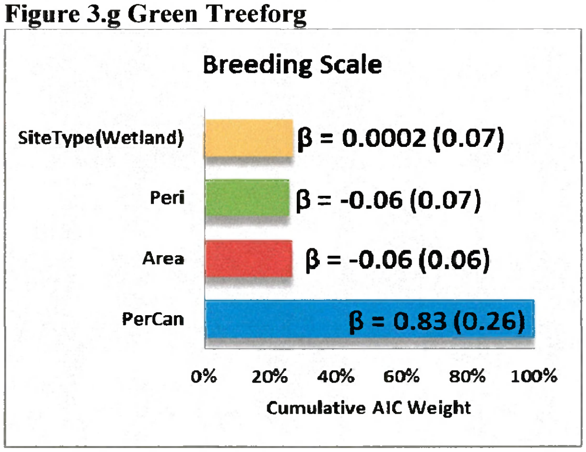


Figure 3.h Green Frog

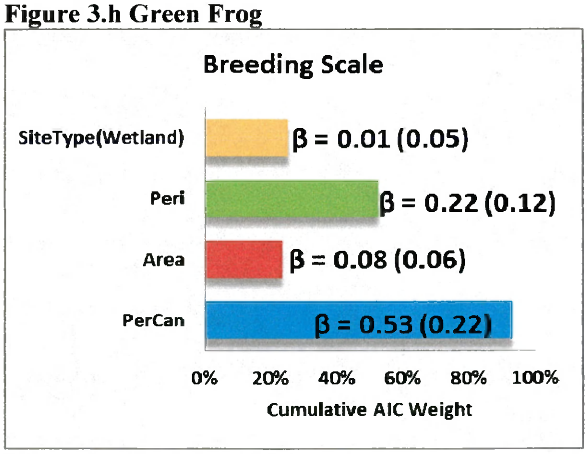


Figure 3.i Northern Cricket Frog

Figures 4.a--c The relative effects of each site-specific covariate on occupancy at the migration life-history scale; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen.**

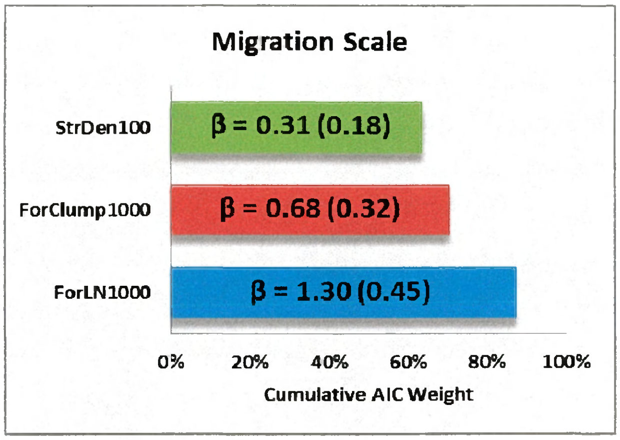


Figure 4.a Pickerel Frog

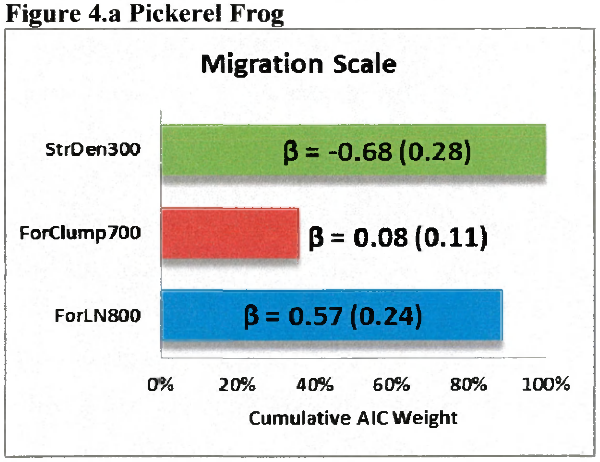


Figure 4.b Southern Leopard Frog

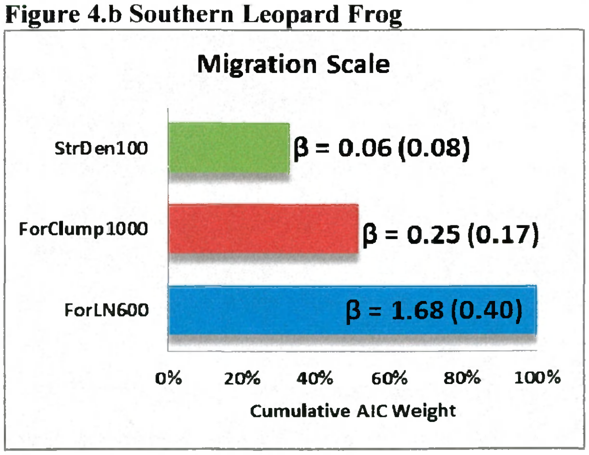


Figure 4.c Spring Peeper

Figures 4.d-f The relative effects of each site-specific covariate on occupancy at the migration life-history scale; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen.**

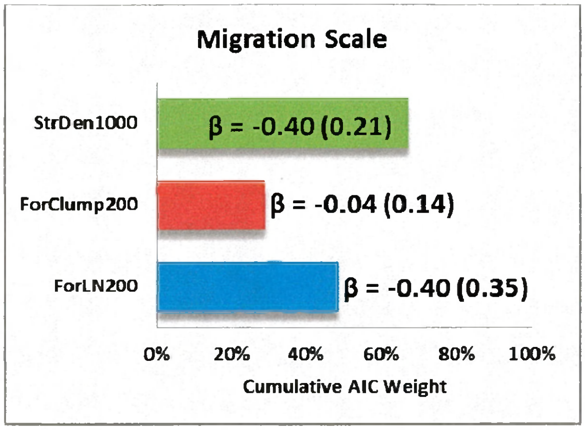


Figure 4.d American Bullfrog

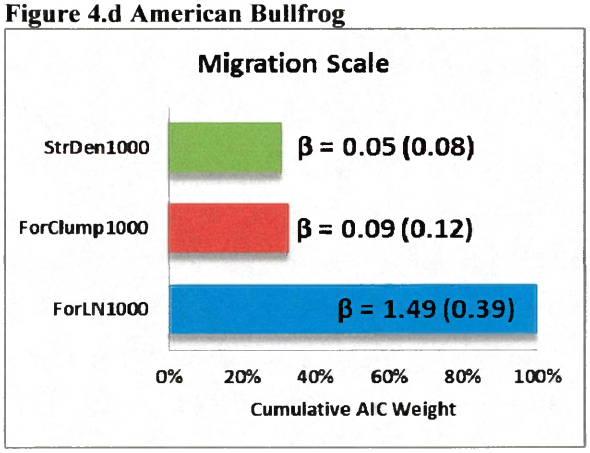


Figure 4.e Cope's Gray Treefrog

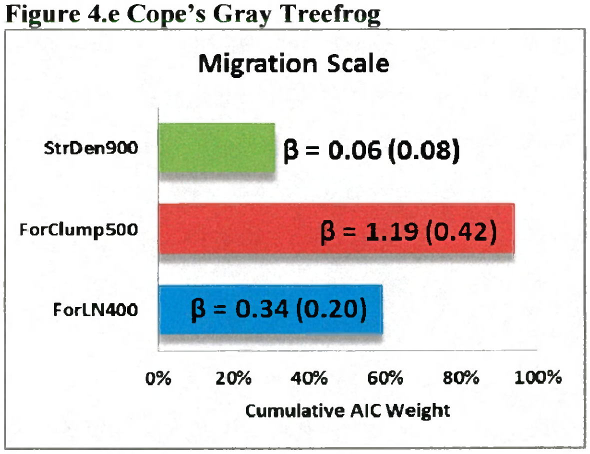


Figure 4.f Fowler's Toad

Figures 4.d-f The relative effects of each site-specific covariate on occupancy at the migration life-history scale; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen.**

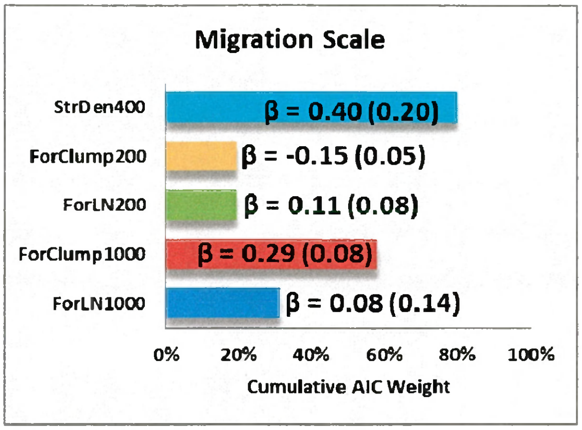


Figure 4.g Green Treeforg

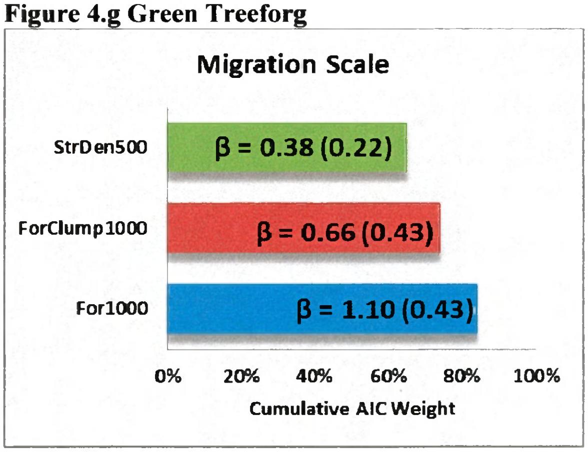


Figure 4.h Green Frog

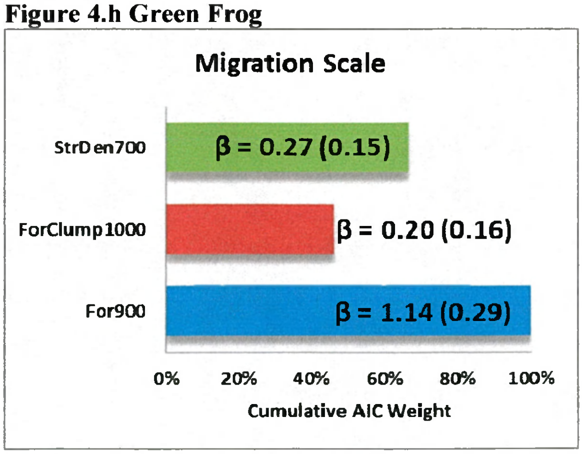


Figure 4.i Northern Cricket Frog

Figures 5.a--c The relative effects of each site-specific covariate on occupancy at the dispersal life-history scale; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

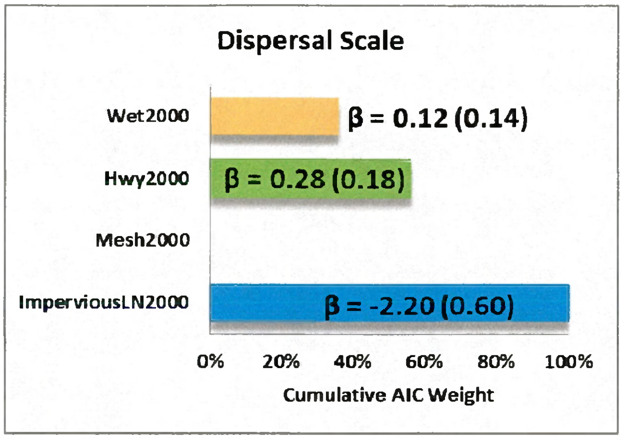


Figure 5.a Pickerel Frog

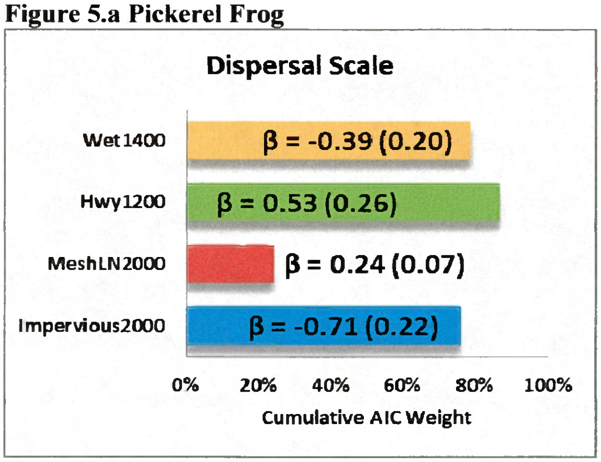


Figure 5.b Southern Leopard Frog

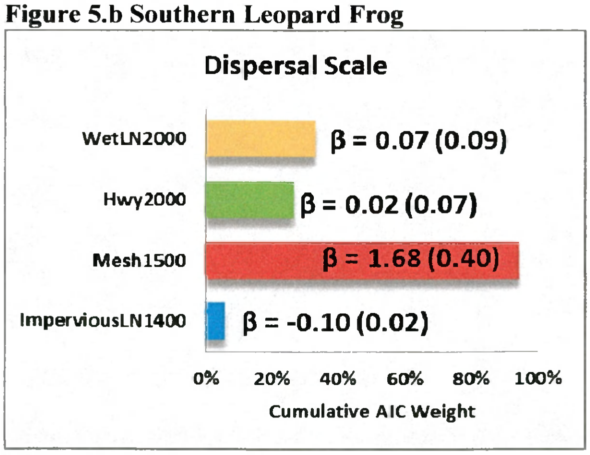


Figure 5.c Spring Peeper

Figures 5.d-f The relative effects of each site-specific covariate on occupancy at the dispersal life-history scale; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

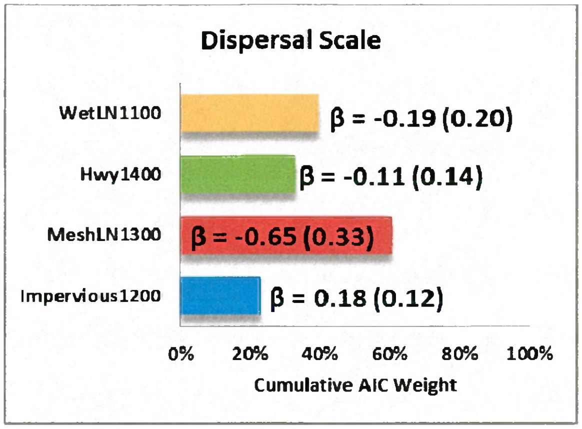


Figure 5.d American Bullfrog

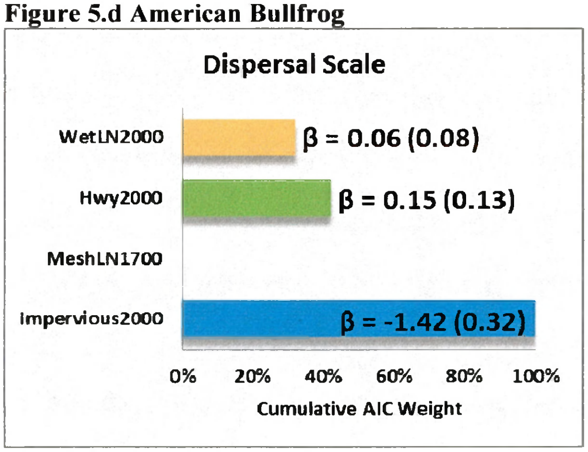


Figure 5.e Cope's Gray Treefrog

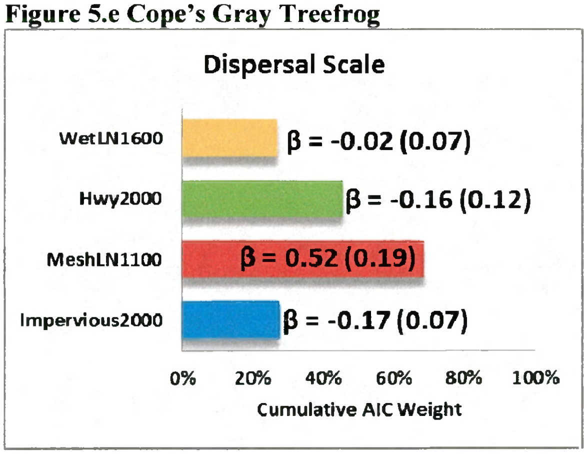


Figure 5.f Fowler's Toad

Figures 5.g-i The relative effects of each site-specific covariate on occupancy at the dispersal life-history scale; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

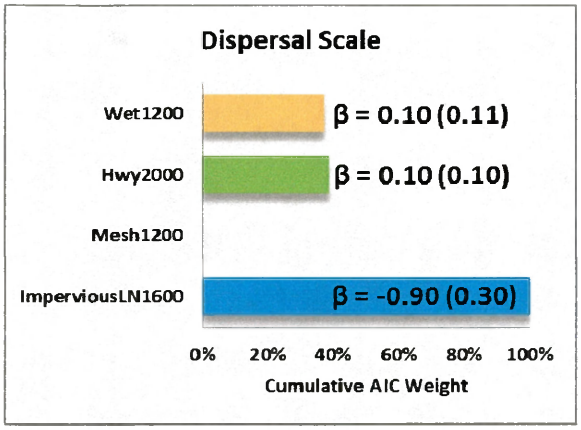


Figure 5.g Green Treeforg

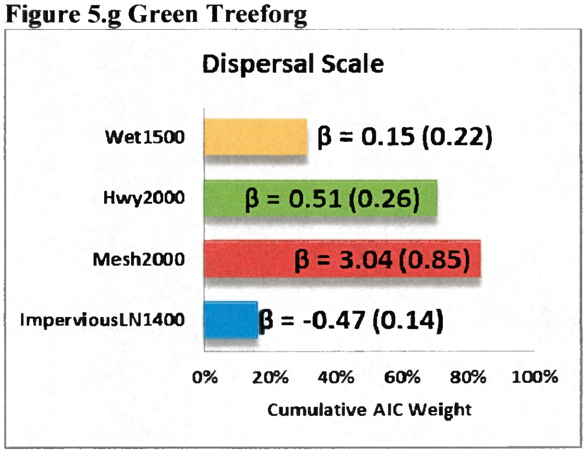


Figure 5.h Green Frog

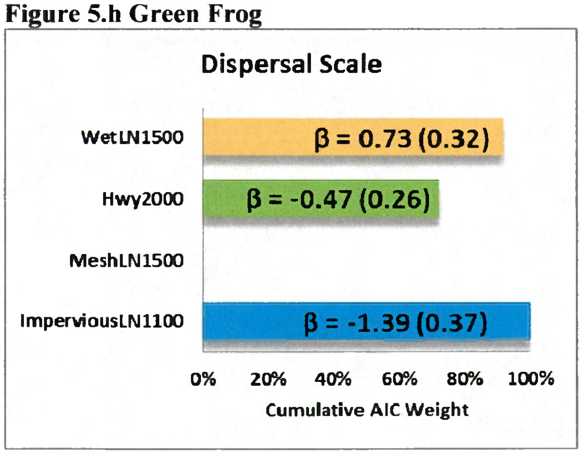


Figure 5.i Northern Cricket Frog

Figure 6.a The relative effects of each site-specific covariate on pickerel frog occupancy for the multi-scale model; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

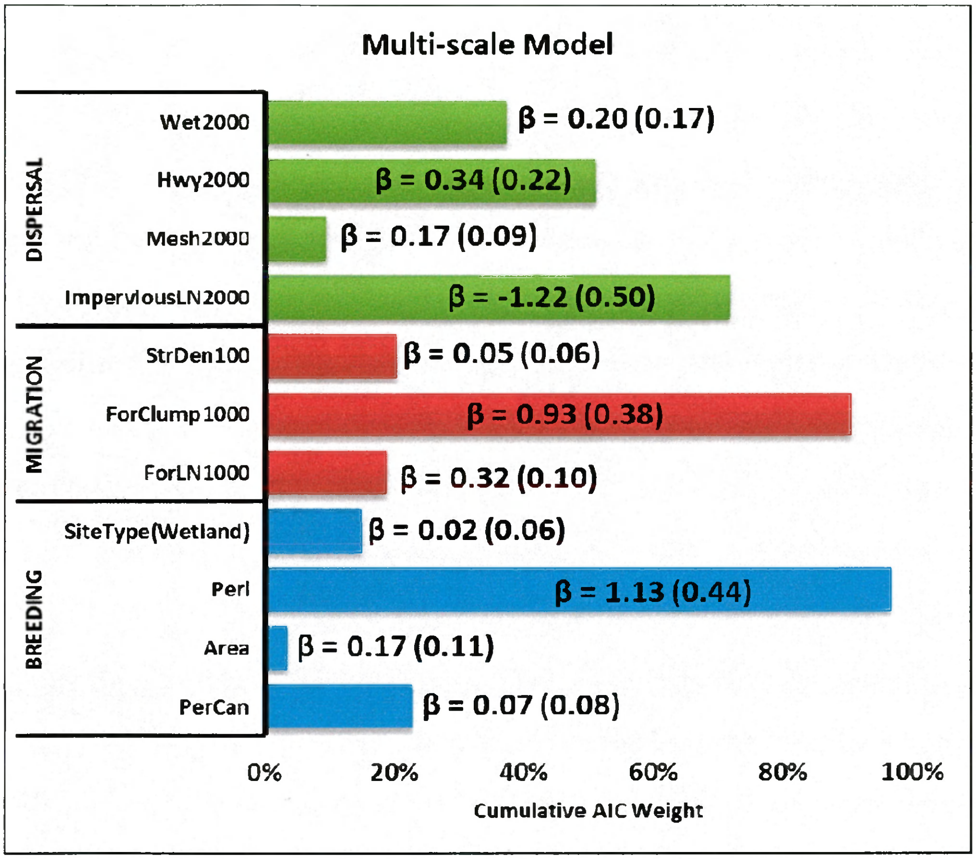


Figure 6.b The relative effects of each site-specific covariate on southern leopard frog occupancy for the multi-scale model; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

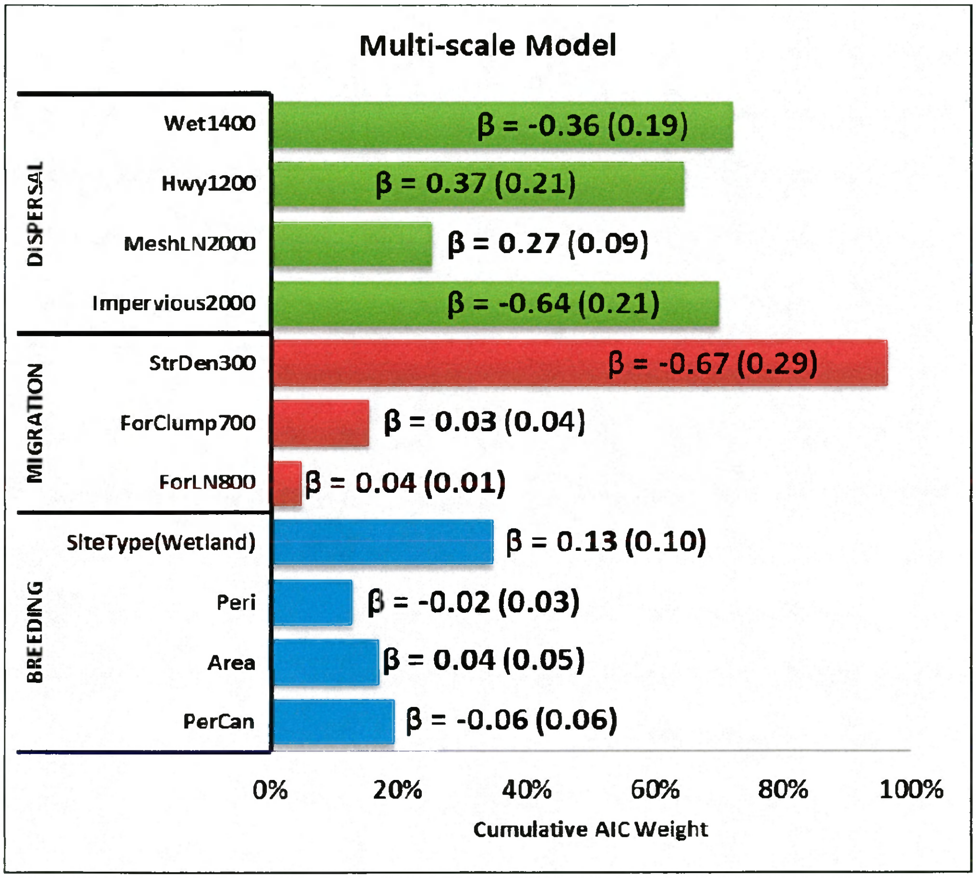


Figure 6.c The relative effects of each site-specific covariate on spring peeper occupancy for the multi-scale model; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

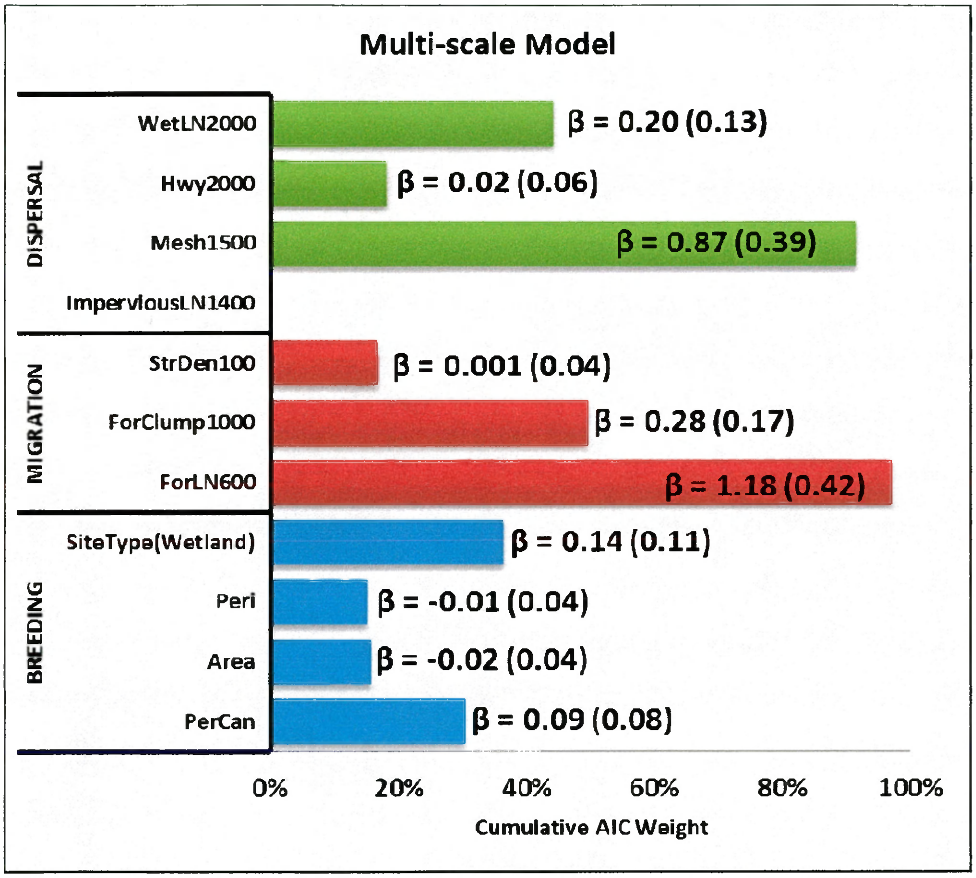


Figure 6.d The relative effects of each site-specific covariate on American bullfrog occupancy for the multi-scale model; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

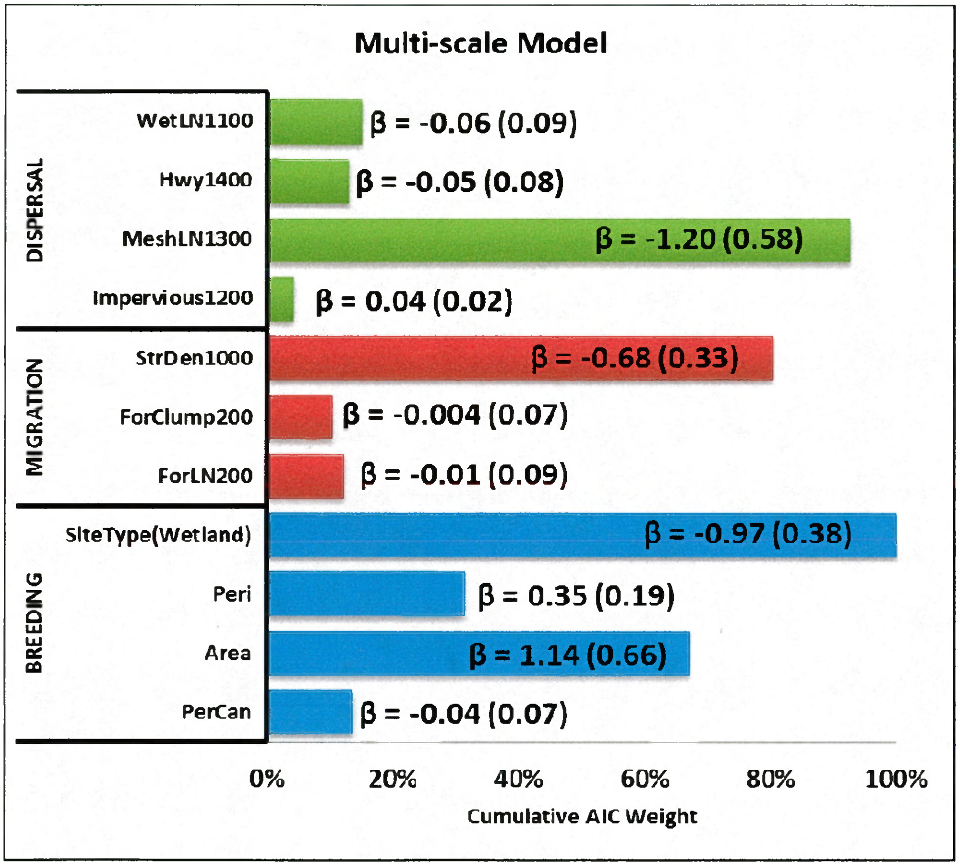


Figure 6.e The relative effects of each site-specific covariate on Cope's gray treefrog occupancy for the multi-scale model; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

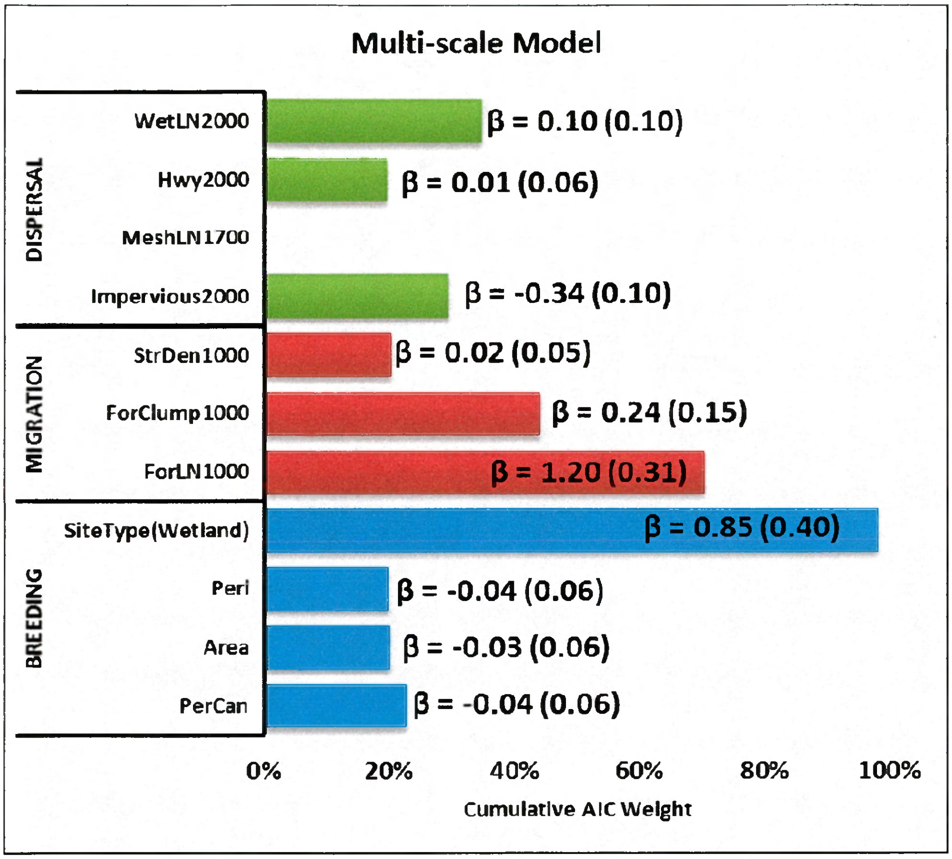


Figure 6.f The relative effects of each site-specific covariate on Fowler's toad occupancy for the multi-scale model; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

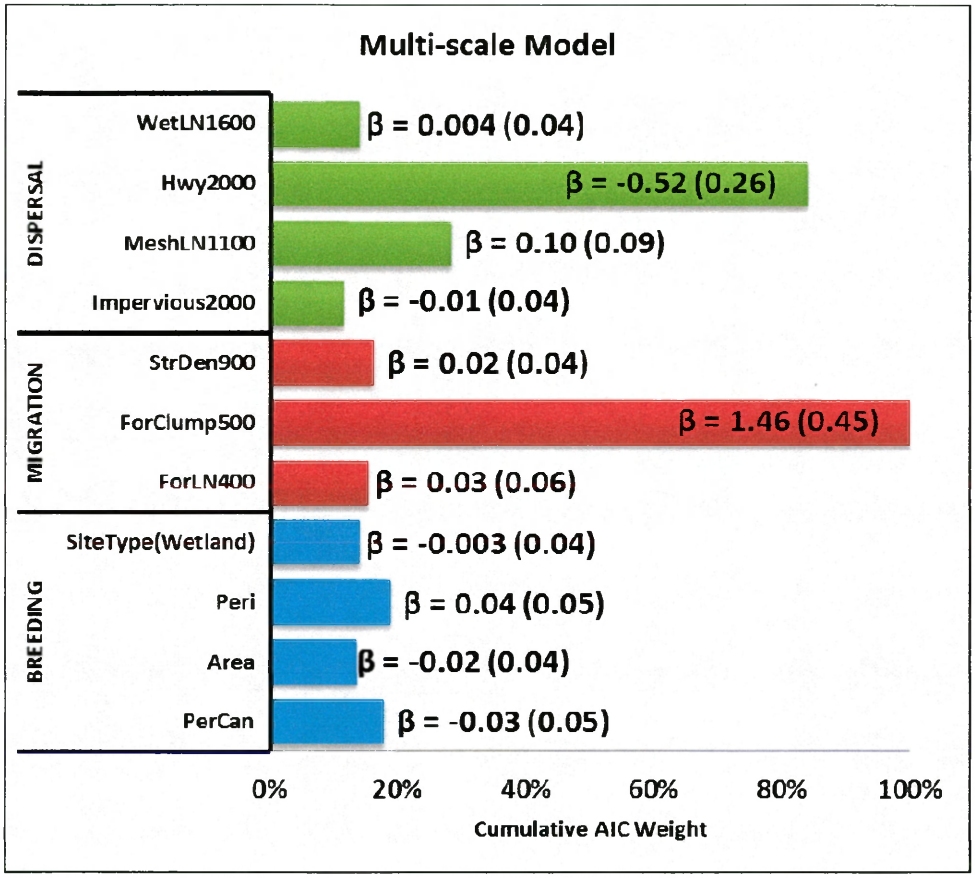


Figure 6.g The relative effects of each site-specific covariate on green treefrog occupancy for the multi-scale model; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

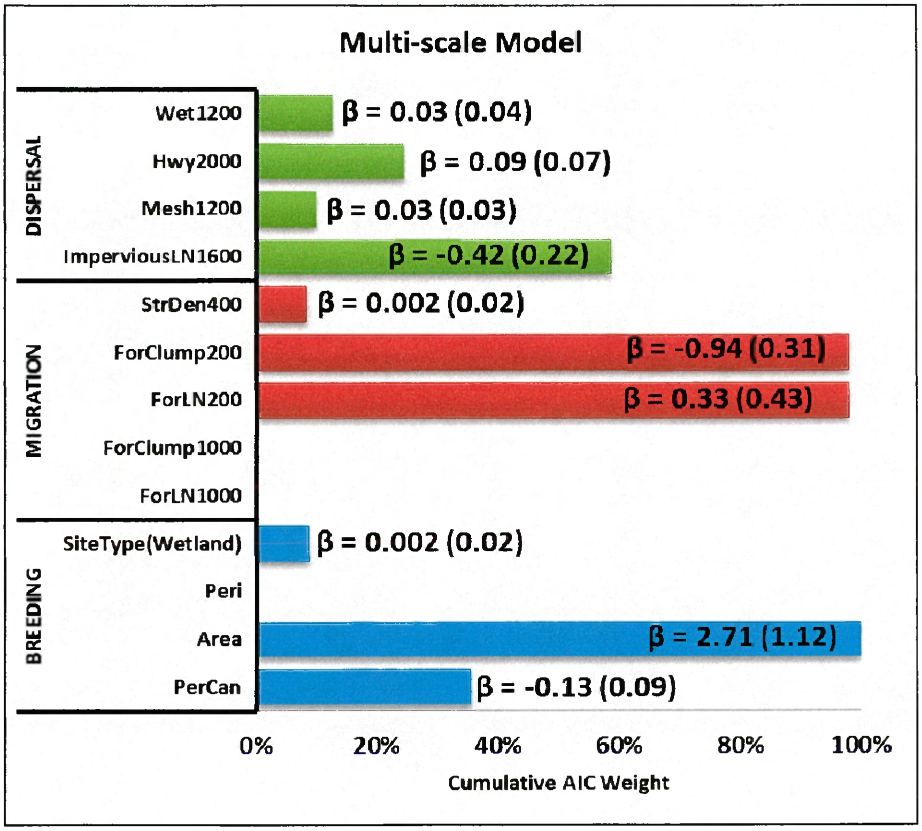


Figure 6.h The relative effects of each site-specific covariate on green frog occupancy for the multi-scale model; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

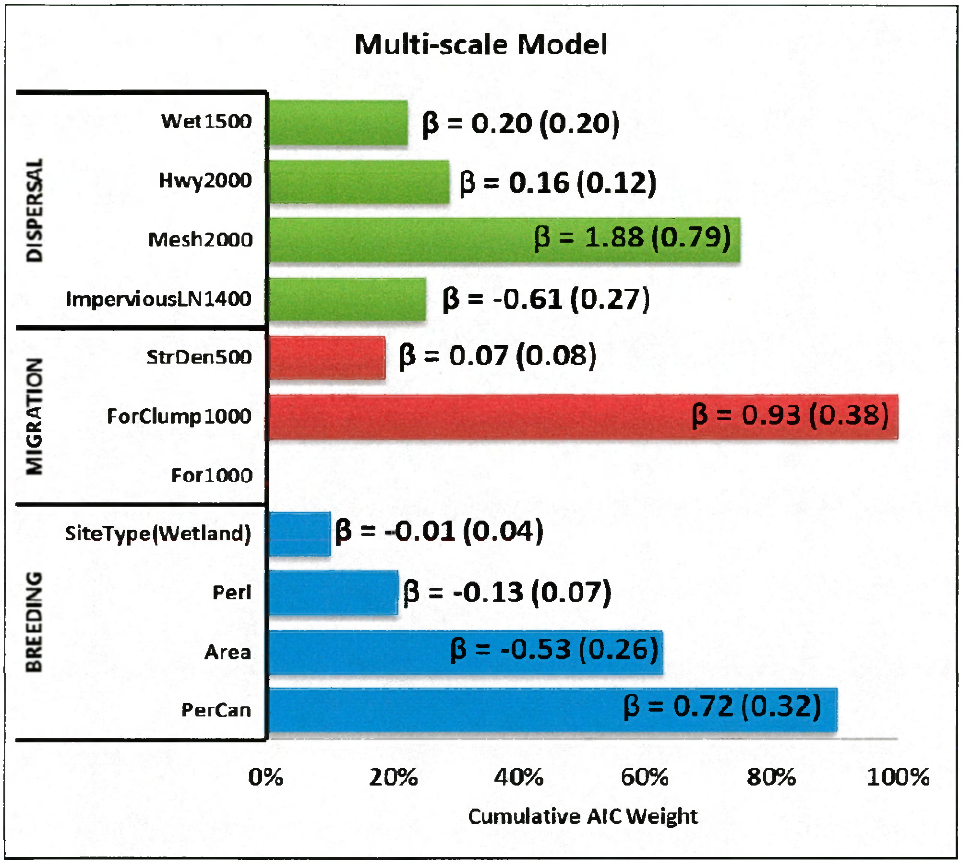
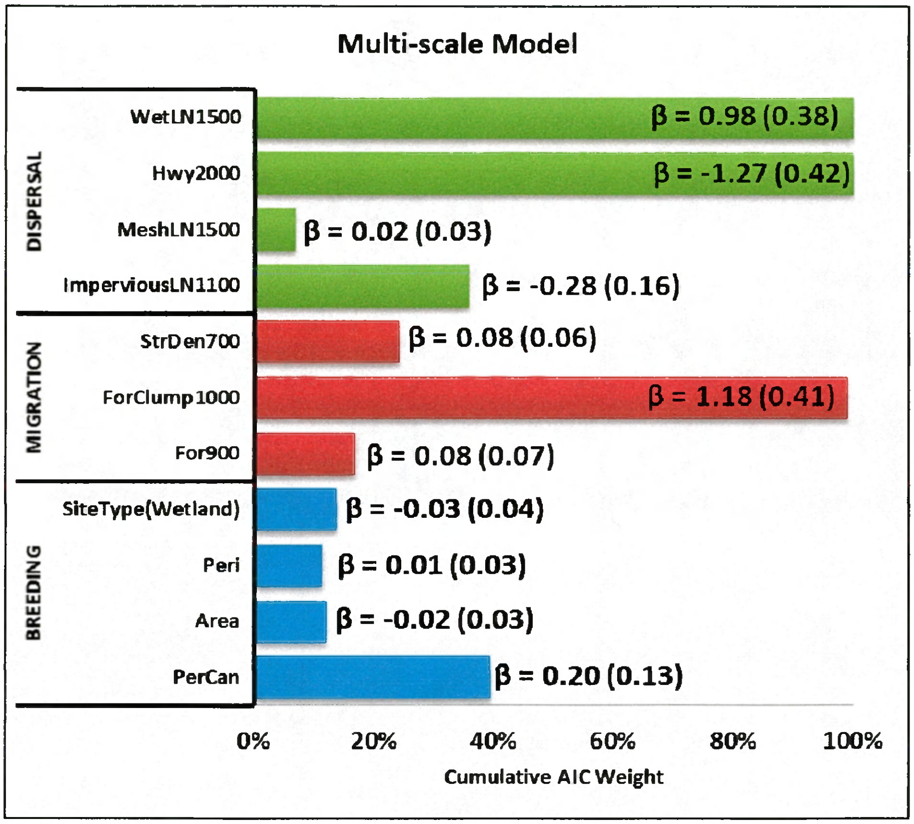


Figure 6.i The relative effects of each site-specific covariate on northern cricket frog occupancy for the multi-scale model; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight, with the corresponding model averaged coefficients and standard errors. Covariate names followed by a numerical value indicate the covariate's extent and a LN indicates a pseudo-threshold relationship. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.



Figures 7.a-c The relative effects of each site-specific covariate on site occupancy for all species at the breeding, migration, and dispersal scales; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**. Species names are: Pickerel Frog = **PIFR**, Southern Leopard Frog = **SLFR**, Spring Peeper = **SPPE**, American Bullfrog = **AMBU**, Cope's Gray Treefrog = **CGTR**, Fowler's Toad = **FOTO**, Green Treefrog = **GNTR**, Green Frog = **GRFR**, and Northern Cricket Frog = **NCFR**.

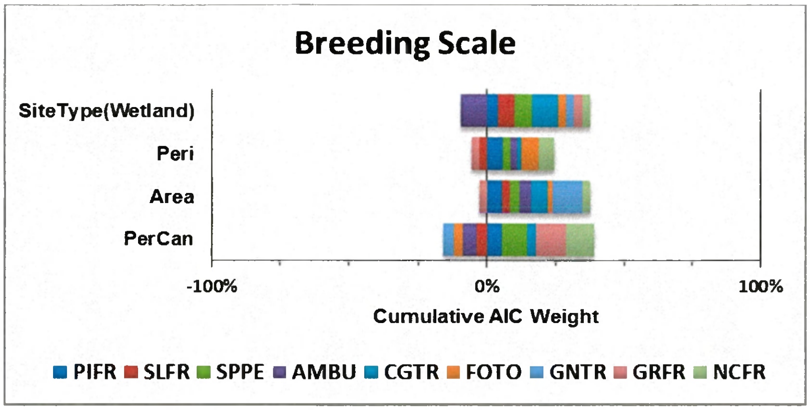


Figure 7.a

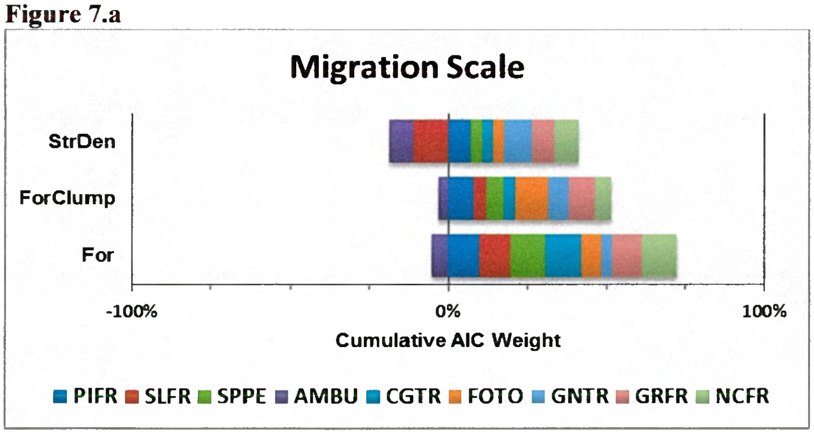


Figure 7.b

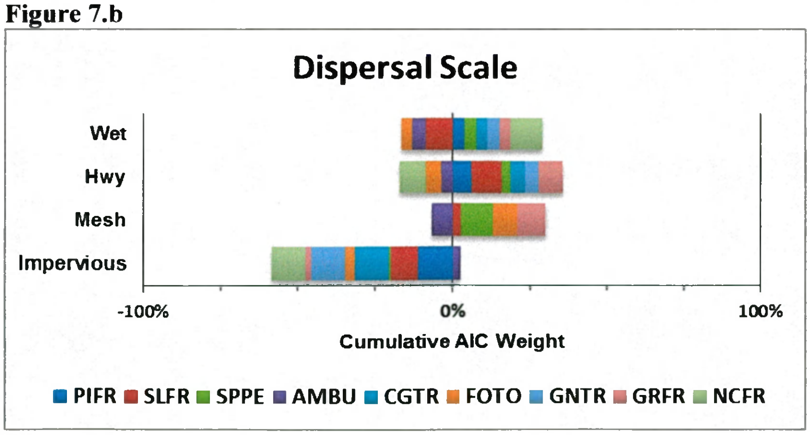
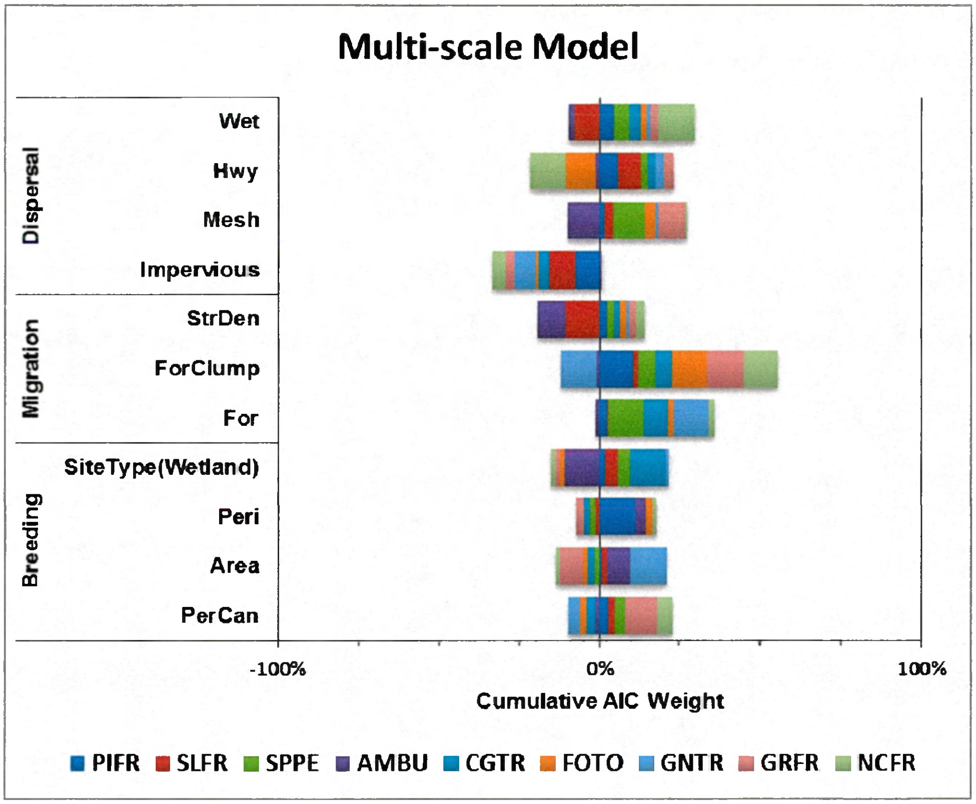


Figure 7.c

Figure 7.d The relative effects of each site-specific covariate on site occupancy for all species for the multi-scale model; displayed as the cumulative AIC weights of the covariates falling within the confidence set, 10% of the highest Akaike weight. Covariate names are: Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType(Wetland)**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**. Species names are: Pickerel Frog = **PIFR**, Southern Leopard Frog = **SLFR**, Spring Peeper = **SPPE**, American Bullfrog = **AMBU**, Cope's Gray Treefrog = **CGTR**, Fowler's Toad = **FOTO**, Green Treefrog = **GNTR**, Green Frog = **GRFR**, and Northern Cricket Frog = **NCFR**.



Appendix 1 Pickerel frog AIC model selection results for the analysis of occupancy. All candidate models within confidence set, 10% of the highest Akaike weight, are displayed, as well as the "null" model without covariates. Ψ is the occupancy probability and p is the detection probability. Covariate names followed by a numerical value indicate the covariates extent, a LN indicates a pseudo-threshold relationship, and INT indicates an interaction term was included. Covariate names are: Background Noise Index = **Noise**, Beaufort Wind Score = **Beau**, Days Since Rain = **DaysRain**, Days Since Above Average Rain of Survey Period = **DaysAvgRain**, Sky and Weather Condition = **Sky**, Time of Day = **Time**, Time since Sunset = **Sunset**, Julian Date = **Jul**, Julian Date Quadratic Term = **JulSq**, Temperature = **Temp**, Wind Speed = **Wind**, Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

Appendix 1.a Pickerel Frog Survey-specific Covariates AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)p(Temp,Wind,Jul,JulSq)	313.05	0.00	0.28	6	301.05
Ψ(.)p(Wind,DaysRain,Jul,JulSq)	313.20	0.14	0.26	6	301.20
Ψ(.)p(Wind,Jul,JulSq,DaysRainLN)	314.78	1.73	0.12	6	302.78
Ψ(.)p(Wind,Jul,JulSq,DaysAvgRainLN)	315.52	2.47	0.08	6	303.52
Ψ(.)p(Wind,Jul,JulSq)	316.10	3.05	0.06	5	306.10
Ψ(.)p(Wind,DaysAvgRain,Jul,JulSq)	316.14	3.09	0.06	6	304.14

Appendix 1.b Pickerel Frog Percent Forest Cover AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForLN1000)	281.83	0.00	0.46	7	267.83
Ψ(ForLN900)	283.33	1.50	0.22	7	269.33
Ψ(For1000)	284.44	2.61	0.12	7	270.44
Ψ(ForLN800)	285.31	3.48	0.08	7	271.31
Ψ(For900)	286.04	4.21	0.06	7	272.04
Ψ(.)	313.05	31.22	0.00	6	301.05

Appendix 1.c Pickerel Frog Forest Clumpiness Index AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForClump1000)	286.22	0.00	0.71	7	272.22
Ψ(ForClump900)	288.69	2.47	0.21	7	274.69
Ψ(ForClump800)	291.22	5.00	0.06	7	277.22
Ψ(ForClump700)	294.07	7.86	0.01	7	280.07
Ψ(ForClump600)	294.33	8.11	0.01	7	280.33
Ψ(.)	313.05	26.84	0.00	6	301.05

Appendix 1 continued.

Appendix 1.d Pickerel Frog Percent Forest Cover/Clumpiness Interaction AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ForLN1000,ForClump1000)	280.80	0.00	0.19	8	264.80
Ψ(For1000,ForClump1000)	281.83	1.02	0.12	8	265.83
Ψ(ForLN1000)	281.83	1.03	0.12	7	267.83
Ψ(ForLN900,ForClump900)	282.25	1.45	0.09	8	266.25
Ψ(ForLN1000,ForClump1000,ForClumpINTLN1000)	282.79	1.98	0.07	9	264.79
Ψ(For1000,ForClump1000,ForClumpINT1000)	283.17	2.37	0.06	9	265.17
Ψ(ForLN900)	283.33	2.53	0.05	7	269.33
Ψ(For900,ForClump900)	283.42	2.61	0.05	8	267.42
Ψ(ForLN900,ForClump900,ForClumpINTLN900)	284.21	3.40	0.04	9	266.21
Ψ(For1000)	284.44	3.64	0.03	7	270.44
Ψ(For900,ForClump900,ForClumpINT900)	284.56	3.75	0.03	9	266.56
Ψ(ForLN800,ForClump800)	284.84	4.04	0.03	8	268.84
Ψ(ForLN800)	285.31	4.51	0.02	7	271.31
Ψ(.)	313.05	32.25	0.00	6	301.05

Appendix 1.e Pickerel Frog Stream Density AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(StrDen100)	309.33	0.00	0.29	7	295.33
Ψ(StrDen700)	311.35	2.02	0.11	7	297.35
Ψ(StrDen600)	311.49	2.17	0.10	7	297.49
Ψ(StrDen200)	311.70	2.38	0.09	7	297.70
Ψ(StrDen500)	311.92	2.59	0.08	7	297.92
Ψ(StrDen900)	312.32	2.99	0.07	7	298.32
Ψ(StrDen300)	312.34	3.02	0.06	7	298.34
Ψ(StrDen800)	312.41	3.08	0.06	7	298.41
Ψ(StrDen1000)	312.61	3.29	0.06	7	298.61
Ψ(StrDen400)	313.02	3.69	0.05	7	299.02
Ψ(.)	313.05	3.73	0.05	6	301.05

Appendix 1.f Pickerel Frog Percent NLCD Impervious Surface AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ImperviousLN2000)	277.65	0.00	0.12	7	263.65
Ψ(ImperviousLN1900)	277.89	0.24	0.11	7	263.89

Appendix 1 continued.

Ψ(ImperviousLN1800)	278.24	0.59	0.09	7	264.24
Ψ(ImperviousLN1700)	278.41	0.76	0.08	7	264.41
Ψ(ImperviousLN1600)	278.63	0.98	0.07	7	264.63
Ψ(ImperviousLN1500)	278.72	1.07	0.07	7	264.72
Ψ(ImperviousLN1400)	278.86	1.20	0.07	7	264.86
Ψ(ImperviousLN1300)	279.03	1.38	0.06	7	265.03
Ψ(ImperviousLN1200)	279.17	1.51	0.06	7	265.17
Ψ(ImperviousLN1100)	279.53	1.88	0.05	7	265.53
Ψ(Impervious1700)	280.62	2.97	0.03	7	266.62
Ψ(Impervious1600)	280.70	3.05	0.03	7	266.70
Ψ(Impervious1500)	280.72	3.07	0.03	7	266.72
Ψ(Impervious2000)	280.81	3.16	0.03	7	266.81
Ψ(Impervious1900)	280.85	3.19	0.02	7	266.85
Ψ(Impervious1800)	280.90	3.25	0.02	7	266.90
Ψ(Impervious1400)	280.96	3.31	0.02	7	266.96
Ψ(Impervious1300)	281.46	3.81	0.02	7	267.46
Ψ(Impervious1200)	281.92	4.27	0.01	7	267.92
Ψ(.)	313.05	35.40	0.00	6	301.05

Appendix 1.g Pickerel Frog Effective Mesh Size AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(Mesh2000)	287.46	0.00	0.21	7	273.46
Ψ(Mesh1900)	288.17	0.71	0.15	7	274.17
Ψ(Mesh1800)	289.02	1.56	0.10	7	275.02
Ψ(Mesh1700)	289.07	1.60	0.09	7	275.07
Ψ(Mesh1600)	289.79	2.32	0.06	7	275.79
Ψ(MeshLN2000)	290.19	2.73	0.05	7	276.19
Ψ(Mesh1500)	290.19	2.73	0.05	7	276.19
Ψ(MeshLN1900)	290.71	3.24	0.04	7	276.71
Ψ(Mesh1400)	290.72	3.26	0.04	7	276.72
Ψ(Mesh1300)	291.14	3.67	0.03	7	277.14
Ψ(MeshLN1800)	291.33	3.87	0.03	7	277.33
Ψ(MeshLN1700)	291.35	3.89	0.03	7	277.35
Ψ(Mesh1200)	291.76	4.30	0.02	7	277.76
Ψ(.)	313.05	25.59	0.00	6	301.05

Appendix 1 continued.

Appendix 1.h Pickerel Frog Highway Density AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Hwy2000)	310.95	0.00	0.15	7	296.95
Ψ(Hwy1700)	311.42	0.47	0.12	7	297.42
Ψ(Hwy1900)	311.43	0.48	0.12	7	297.43
Ψ(Hwy1800)	311.52	0.57	0.11	7	297.52
Ψ(Hwy1600)	311.74	0.79	0.10	7	297.74
Ψ(Hwy1500)	312.43	1.47	0.07	7	298.43
Ψ(Hwy1100)	312.47	1.52	0.07	7	298.47
Ψ(Hwy1400)	312.56	1.60	0.07	7	298.56
Ψ(Hwy1200)	312.59	1.64	0.07	7	298.59
Ψ(Hwy1300)	312.83	1.87	0.06	7	298.83
Ψ(.)	313.05	2.10	0.05	6	301.05

Appendix 1.i Pickerel Frog Percent Wetland Cover AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Wet2000)	306.85	0.00	0.15	7	292.85
Ψ(Wet1900)	307.03	0.18	0.14	7	293.03
Ψ(Wet1800)	307.27	0.42	0.12	7	293.27
Ψ(Wet1700)	307.73	0.88	0.10	7	293.73
Ψ(Wet1600)	308.36	1.51	0.07	7	294.36
Ψ(Wet1500)	308.61	1.76	0.06	7	294.61
Ψ(Wet1400)	308.98	2.13	0.05	7	294.98
Ψ(WetLN1800)	309.16	2.31	0.05	7	295.16
Ψ(WetLN1700)	309.50	2.65	0.04	7	295.50
Ψ(Wet1300)	309.50	2.66	0.04	7	295.50
Ψ(WetLN1900)	309.60	2.75	0.04	7	295.60
Ψ(Wet1200)	309.76	2.92	0.03	7	295.76
Ψ(WetLN2000)	309.88	3.04	0.03	7	295.88
Ψ(Wet1100)	310.20	3.35	0.03	7	296.20
Ψ(WetLN1600)	310.43	3.58	0.02	7	296.43
Ψ(.)	313.05	6.20	0.01	6	301.05

Appendix 1.j Pickerel Frog Local Scale AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(PerCan,Area)	293.98	0.00	0.18	8	277.98
Ψ(Peri)	294.04	0.06	0.18	7	280.04

Appendix 1 continued.

Ψ(Area)	294.27	0.28	0.16	7	280.27
Ψ(PerCan,Peri)	294.54	0.56	0.14	8	278.54
Ψ(Peri,SiteType)	294.65	0.66	0.13	8	278.65
Ψ(PerCan,Peri,SiteType)	295.68	1.70	0.08	9	277.68
Ψ(Area,SiteType)	295.78	1.79	0.07	8	279.78
Ψ(PerCan,Area,SiteType)	295.81	1.83	0.07	9	277.81
Ψ(.)	313.05	19.07	0.00	6	301.05

Appendix 1.k Pickerel Frog Migration Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForLN1000,ForClump1000,StrDen100)	279.95	0.00	0.34	9	261.95
Ψ(ForLN1000,ForClump1000)	280.80	0.86	0.22	8	264.80
Ψ(ForLN1000,StrDen100)	281.49	1.55	0.16	8	265.49
Ψ(ForLN1000)	281.83	1.88	0.13	7	267.83
Ψ(ForClump1000,StrDen100)	281.97	2.02	0.12	8	265.97
Ψ(.)	313.05	33.10	0.00	6	301.05

Appendix 1.l Pickerel Frog Dispersal Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ImperviousLN2000,Hwy2000)	277.17	0.00	0.35	8	261.17
Ψ(ImperviousLN2000)	277.65	0.48	0.28	7	263.65
Ψ(ImperviousLN2000,Wet2000,Hwy2000)	278.33	1.16	0.20	9	260.33
Ψ(ImperviousLN2000,Wet2000)	278.84	1.67	0.15	8	262.84
Ψ(.)	313.05	35.88	0.00	6	301.05

Appendix 1.m Pickerel Frog Multi-scale Model AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(Peri,ForClump1000,ImperviousLN2000,Hwy2000)	263.94	0.00	0.07	10	243.94
Ψ(Peri,ForClump1000,ImperviousLN2000)	264.38	0.43	0.06	9	246.38
Ψ(Peri,ForClump1000,ImperviousLN2000,Wet2000,Hwy2000)	265.14	1.19	0.04	11	243.14
Ψ(PerCan,Peri,ForClump1000,ImperviousLN2000,Hwy2000)	265.17	1.23	0.04	11	243.17
Ψ(Peri,ForClump1000,StrDen100,ImperviousLN2000,Hwy2000)	265.30	1.36	0.04	11	243.30
Ψ(Peri,ForClump1000,ImperviousLN2000,Wet2000)	265.37	1.42	0.03	10	245.37
Ψ(PerCan,Peri,ForClump1000,ImperviousLN2000)	265.64	1.70	0.03	10	245.64
Ψ(Peri,ForClump1000,StrDen100,ImperviousLN2000)	265.71	1.76	0.03	10	245.71
Ψ(Peri,SiteType,ForClump1000,ImperviousLN2000,Hwy2000)	265.93	1.98	0.03	11	243.93

Appendix 1 continued.

Ψ(Peri,SiteType,ForClump1000,ImperviousLN2000)	266.19	2.25	0.02	10	246.19
Ψ(Peri,ForLN1000,Wet2000,Hwy2000)	266.28	2.33	0.02	10	246.28
Ψ(Peri,ForClump1000,StrDen100,ImperviousLN2000,Wet2000)	266.38	2.43	0.02	11	244.38
Ψ(Peri,ForClump1000,Mesh2000,Hwy2000)	266.42	2.47	0.02	10	246.42
Ψ(PerCan,Peri,ForClump1000,ImperviousLN2000,Wet2000)	266.49	2.54	0.02	11	244.49
Ψ(Peri,ForLN1000,ForClump1000,Wet2000)	266.77	2.82	0.02	10	246.77
Ψ(Peri,ForLN1000,ForClump1000,Wet2000,Hwy2000)	266.82	2.87	0.02	11	244.82
Ψ(PerCan,Peri,ForLN1000,Wet2000,Hwy2000)	267.03	3.08	0.02	11	245.03
Ψ(PerCan,Peri,ForClump1000,StrDen100,ImperviousLN2000)	267.22	3.27	0.01	11	245.22
Ψ(Peri,SiteType,ForClump1000,ImperviousLN2000,Wet2000)	267.36	3.41	0.01	11	245.36
Ψ(PerCan,Peri,ForLN1000,ForClump1000,Wet2000)	267.45	3.50	0.01	11	245.45
Ψ(Peri,SiteType,ForClump1000,StrDen100,ImperviousLN2000)	267.47	3.52	0.01	11	245.47
Ψ(PerCan,Peri,SiteType,ForClump1000,ImperviousLN2000)	267.62	3.67	0.01	11	245.62
Ψ(Peri,SiteType,ForClump1000,Mesh2000,Hwy2000)	267.80	3.86	0.01	11	245.80
Ψ(Peri,ForLN1000,ForClump1000,StrDen100,Wet2000)	267.82	3.87	0.01	11	245.82
Ψ(Peri,ForLN1000,Wet2000)	267.88	3.93	0.01	9	249.88
Ψ(Peri,ForLN1000,StrDen100,Wet2000,Hwy2000)	267.88	3.94	0.01	11	245.88
Ψ(Peri,ForClump1000,Wet2000,Mesh2000,Hwy2000)	267.94	4.00	0.01	11	245.94
Ψ(Peri,ForClump1000,StrDen100,Mesh2000,Hwy2000)	268.11	4.17	0.01	11	246.11
Ψ(Peri,ForLN1000,ForClump1000)	268.13	4.18	0.01	9	250.13
Ψ(PerCan,Area,ForClump1000,ImperviousLN2000,Hwy2000)	268.20	4.25	0.01	11	246.20
Ψ(Peri,SiteType,ForLN1000,Wet2000,Hwy2000)	268.27	4.33	0.01	11	246.27
Ψ(Peri,ForClump1000,Mesh2000)	268.32	4.38	0.01	9	250.32
Ψ(PerCan,Peri,ForClump1000,Mesh2000,Hwy2000)	268.34	4.39	0.01	11	246.34
Ψ(Area,ForClump1000,ImperviousLN2000,Hwy2000)	268.47	4.53	0.01	10	248.47
Ψ(Area,ForClump1000,ImperviousLN2000)	268.50	4.55	0.01	9	250.50
Ψ(.)	313.05	49.11	0.00	6	301.05

Appendix 2 Southern leopard frog AIC model selection results for the analysis of occupancy. All candidate models within confidence set, 10% of the highest Akaike weight, are displayed, as well as the "null" model without covariates. Ψ is the occupancy probability and p is the detection probability. Covariate names followed by a numerical value indicate the covariates extent, a LN indicates a pseudo-threshold relationship, and INT indicates an interaction term was included. Covariate names are: Background Noise Index = **Noise**, Beaufort Wind Score = **Beau**, Days Since Rain = **DaysRain**, Days Since Above Average Rain of Survey Period = **DaysAvgRain**, Sky and Weather Condition = **Sky**, Time of Day = **Time**, Time since Sunset = **Sunset**, Julian Date = **Jul**, Julian Date Quadratic Term = **JulSq**, Temperature = **Temp**, Wind Speed = **Wind**, Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

Appendix 2.a Southern Leopard Frog Survey-specific Covariates AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(.)p(DaysRain,Noise1,Noise2,Noise3and4Com)	373.00	0.00	0.12	6	361.00
Ψ(.)p(Wind,Jul,JulSq,DaysAvgRainLN)	374.25	1.25	0.07	6	362.25
Ψ(.)p(DaysRain,Jul,JulSq)	374.40	1.40	0.06	5	364.40
Ψ(.)p(Jul,JulSq,DaysAvgRainLN)	374.43	1.43	0.06	5	364.43
Ψ(.)p(Wind,DaysRain,Jul,JulSq)	374.62	1.62	0.05	6	362.62
Ψ(.)p(Temp,DaysRain,Jul,JulSq)	375.50	2.50	0.04	6	363.50
Ψ(.)p(Jul,JulSq,DaysAvgRainLN,SunsetLN)	375.97	2.97	0.03	6	363.97
Ψ(.)p(Jul,JulSq,DaysAvgRainLN,TimeLN)	376.02	3.02	0.03	6	364.02
Ψ(.)p(Jul,JulSq,DaysRainLN)	376.06	3.07	0.03	5	366.06
Ψ(.)p(Time,Jul,JulSq,DaysAvgRainLN)	376.13	3.13	0.03	6	364.13
Ψ(.)p(DaysRain,Jul,JulSq,SunsetLN)	376.15	3.15	0.03	6	364.15
Ψ(.)p(DaysRain,Jul,JulSq,TimeLN)	376.24	3.24	0.02	6	364.24
Ψ(.)p(Noise1,Noise2,Noise3and4Com,DaysRainLN)	376.24	3.24	0.02	6	364.24
Ψ(.)p(DaysRain,Time,Jul,JulSq)	376.28	3.28	0.02	6	364.28
Ψ(.)p(Sunset,Jul,JulSq,DaysAvgRainLN)	376.32	3.32	0.02	6	364.32
Ψ(.)p(Wind,Jul,JulSq,DaysRainLN)	376.35	3.35	0.02	6	364.35
Ψ(.)p(DaysRain,Sunset,Jul,JulSq)	376.37	3.37	0.02	6	364.37
Ψ(.)p(Temp,Jul,JulSq,DaysAvgRainLN)	376.40	3.40	0.02	6	364.40
Ψ(.)p(Temp,DaysRain,Sky1,Sky2thru4Com)	376.82	3.82	0.02	6	364.82
Ψ(.)p(DaysRain,Sky1,Sky2thru4Com)	377.07	4.07	0.02	5	367.07
Ψ(.)p(Temp,Sky1,Sky2thru4Com,DaysRainLN)	377.19	4.19	0.02	6	365.19
Ψ(.)p(Temp,Jul,JulSq,DaysRainLN)	377.24	4.24	0.01	6	365.24

Appendix 2.b Southern Leopard Frog Percent Forest Cover AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ForLN800)	368.21	0.00	0.10	7	354.21
Ψ(ForLN700)	368.32	0.11	0.10	7	354.32

Appendix 2 continued.

Ψ(ForLN1000)	368.49	0.28	0.09	7	354.49
Ψ(ForLN900)	368.52	0.31	0.09	7	354.52
Ψ(ForLN600)	368.99	0.78	0.07	7	354.99
Ψ(For1000)	369.11	0.89	0.07	7	355.11
Ψ(For900)	369.36	1.15	0.06	7	355.36
Ψ(For100)	369.65	1.44	0.05	7	355.65
Ψ(For800)	369.74	1.53	0.05	7	355.74
Ψ(ForLN400)	369.89	1.68	0.04	7	355.89
Ψ(For200)	370.24	2.03	0.04	7	356.24
Ψ(For300)	370.32	2.11	0.04	7	356.32
Ψ(ForLN500)	370.32	2.11	0.04	7	356.32
Ψ(For700)	370.33	2.11	0.04	7	356.33
Ψ(ForLN300)	370.54	2.33	0.03	7	356.54
Ψ(For600)	370.95	2.74	0.03	7	356.95
Ψ(For400)	371.01	2.80	0.03	7	357.01
Ψ(For500)	371.39	3.17	0.02	7	357.39
Ψ(ForLN100)	371.87	3.66	0.02	7	357.87
Ψ(ForLN200)	371.99	3.78	0.02	7	357.99
Ψ(.)	373.00	4.79	0.01	6	361.00

Appendix 2.c Southern Leopard Frog Forest Clumpiness Index AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForClump700)	369.73	0.00	0.20	7	355.73
Ψ(ForClump800)	370.02	0.28	0.17	7	356.02
Ψ(ForClump300)	370.27	0.53	0.15	7	356.27
Ψ(ForClump600)	370.68	0.94	0.12	7	356.68
Ψ(ForClump1000)	370.84	1.10	0.11	7	356.84
Ψ(ForClump900)	371.29	1.55	0.09	7	357.29
Ψ(ForClump100)	371.88	2.15	0.07	7	357.88
Ψ(.)	373.00	3.27	0.04	6	361.00

Appendix 2.d Southern Leopard Frog Percent Forest Cover/Clumpiness Interaction AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForLN800)	368.21	0.00	0.05	7	354.21
Ψ(ForLN700)	368.32	0.11	0.05	7	354.32
Ψ(ForLN1000)	368.49	0.28	0.04	7	354.49
Ψ(ForLN900)	368.52	0.31	0.04	7	354.52

Appendix 2 continued.

Ψ(ForLN600)	368.99	0.78	0.03	7	354.99
Ψ(For1000)	369.11	0.89	0.03	7	355.11
Ψ(For900)	369.36	1.15	0.03	7	355.36
Ψ(For100)	369.65	1.44	0.02	7	355.65
Ψ(ForClump700)	369.73	1.52	0.02	7	355.73
Ψ(For800)	369.74	1.53	0.02	7	355.74
Ψ(ForLN700,ForClump700)	369.81	1.59	0.02	8	353.81
Ψ(ForLN400)	369.89	1.68	0.02	7	355.89
Ψ(ForLN800,ForClump800)	369.90	1.68	0.02	8	353.90
Ψ(ForClump800)	370.02	1.80	0.02	7	356.02
Ψ(For200)	370.24	2.03	0.02	7	356.24
Ψ(ForClump300)	370.27	2.05	0.02	7	356.27
Ψ(For300)	370.32	2.11	0.02	7	356.32
Ψ(ForLN500)	370.32	2.11	0.02	7	356.32
Ψ(For700)	370.33	2.11	0.02	7	356.33
Ψ(ForLN1000,ForClump1000)	370.43	2.22	0.02	8	354.43
Ψ(ForLN900,ForClump900)	370.48	2.27	0.02	8	354.48
Ψ(ForLN300)	370.54	2.33	0.02	7	356.54
Ψ(For300,ForClump300)	370.56	2.35	0.02	8	354.56
Ψ(For700,ForClump700,ForClumpINT700)	370.66	2.45	0.02	9	352.66
Ψ(ForClump600)	370.68	2.46	0.01	7	356.68
Ψ(For800,ForClump800)	370.71	2.49	0.01	8	354.71
Ψ(For100,ForClump100)	370.71	2.50	0.01	8	354.71
Ψ(ForLN600,ForClump600)	370.77	2.56	0.01	8	354.77
Ψ(For1000,ForClump1000)	370.78	2.56	0.01	8	354.78
Ψ(For700,ForClump700)	370.83	2.62	0.01	8	354.83
Ψ(ForClump1000)	370.84	2.62	0.01	7	356.84
Ψ(For600)	370.95	2.74	0.01	7	356.95
Ψ(For400)	371.01	2.80	0.01	7	357.01
Ψ(ForLN500,ForClump500)	371.03	2.81	0.01	8	355.03
Ψ(ForLN400,ForClump400)	371.05	2.84	0.01	8	355.05
Ψ(For900,ForClump900)	371.07	2.86	0.01	8	355.07
Ψ(ForLN700,ForClump700,ForClumpINTLN700)	371.12	2.91	0.01	9	353.12
Ψ(ForClump900)	371.29	3.07	0.01	7	357.29
Ψ(For500)	371.39	3.17	0.01	7	357.39
Ψ(ForLN300,ForClump300)	371.41	3.20	0.01	8	355.41
Ψ(For100,ForClump100,ForClumpINT100)	371.42	3.20	0.01	9	353.42
Ψ(ForLN500,ForClump500,ForClumpINTLN500)	371.52	3.30	0.01	9	353.52
Ψ(For800,ForClump800,ForClumpINT800)	371.59	3.38	0.01	9	353.59
Ψ(ForLN100,ForClump100,ForClumpINTLN100)	371.78	3.57	0.01	9	353.78

Appendix 2 continued.

Ψ(For600,ForClump600)	371.79	3.58	0.01	8	355.79
Ψ(ForLN100)	371.87	3.66	0.01	7	357.87
Ψ(ForClump100)	371.88	3.67	0.01	7	357.88
Ψ(ForLN800,ForClump800,ForClumpINTLN800)	371.89	3.68	0.01	9	353.89
Ψ(For300,ForClump300,ForClumpINT300)	371.99	3.77	0.01	9	353.99
Ψ(ForLN200)	371.99	3.78	0.01	7	357.99
Ψ(For200,ForClump200)	372.14	3.93	0.01	8	356.14
Ψ(For600,ForClump600,ForClumpINT600)	372.18	3.96	0.01	9	354.18
Ψ(ForLN400,ForClump400,ForClumpINTLN400)	372.34	4.13	0.01	9	354.34
Ψ(ForLN900,ForClump900,ForClumpINTLN900)	372.35	4.13	0.01	9	354.35
Ψ(For1000,ForClump1000,ForClumpINT1000)	372.39	4.18	0.01	9	354.39
Ψ(ForLN1000,ForClump1000,ForClumpINTLN1000)	372.40	4.19	0.01	9	354.40
Ψ(ForLN600,ForClump600,ForClumpINTLN600)	372.51	4.29	0.01	9	354.51
Ψ(ForLN100,ForClump100)	372.56	4.34	0.01	8	356.56
Ψ(For900,ForClump900,ForClumpINT900)	372.69	4.48	0.01	9	354.69
Ψ(.)	373.00	4.79	0.00	6	361.00

Appendix 2.e Southern Leopard Frog Stream Density AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(StrDen300)	368.56	0.00	0.25	7	354.56
Ψ(StrDen200)	369.38	0.82	0.17	7	355.38
Ψ(StrDen400)	370.08	1.51	0.12	7	356.08
Ψ(StrDen800)	370.65	2.08	0.09	7	356.65
Ψ(StrDen700)	370.92	2.36	0.08	7	356.92
Ψ(StrDen500)	371.06	2.50	0.07	7	357.06
Ψ(StrDen900)	371.44	2.88	0.06	7	357.44
Ψ(StrDen600)	371.52	2.96	0.06	7	357.52
Ψ(StrDen1000)	372.03	3.47	0.04	7	358.03
Ψ(.)	373.00	4.44	0.03	6	361.00

Appendix 2.f Southern Leopard Frog Percent NLCD Impervious Surface AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(Impervious2000)	367.90	0.00	0.17	7	353.90
Ψ(Impervious1900)	368.32	0.42	0.14	7	354.32
Ψ(Impervious1800)	368.70	0.80	0.11	7	354.70
Ψ(Impervious1700)	369.00	1.10	0.10	7	355.00
Ψ(Impervious1600)	369.36	1.45	0.08	7	355.36

Appendix 2 continued.

	369.79	1.88	0.07	7	355.79
Ψ(Impervious1500)					
Ψ(Impervious1400)	370.34	2.44	0.05	7	356.34
Ψ(Impervious1300)	370.79	2.89	0.04	7	356.79
Ψ(Impervious1200)	371.12	3.21	0.03	7	357.12
Ψ(Impervious1100)	371.24	3.33	0.03	7	357.24
Ψ(ImperviousLN2000)	371.95	4.05	0.02	7	357.95
Ψ(ImperviousLN1900)	372.11	4.21	0.02	7	358.11
Ψ(ImperviousLN1800)	372.26	4.36	0.02	7	358.26
Ψ(ImperviousLN1700)	372.34	4.44	0.02	7	358.34
Ψ(ImperviousLN1600)	372.46	4.55	0.02	7	358.46
Ψ(.)	373.00	5.10	0.01	6	361.00

Appendix 2.g Southern Leopard Frog Effective Mesh Size AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(MeshLN2000)	370.93	0.00	0.11	7	356.93
Ψ(MeshLN1900)	371.38	0.45	0.08	7	357.38
Ψ(MeshLN1800)	371.78	0.85	0.07	7	357.78
Ψ(MeshLN1700)	371.91	0.98	0.07	7	357.91
Ψ(MeshLN1300)	372.03	1.10	0.06	7	358.03
Ψ(MeshLN1600)	372.07	1.13	0.06	7	358.07
Ψ(MeshLN1100)	372.11	1.17	0.06	7	358.11
Ψ(MeshLN1200)	372.12	1.18	0.06	7	358.12
Ψ(MeshLN1500)	372.14	1.21	0.06	7	358.14
Ψ(MeshLN1400)	372.15	1.22	0.06	7	358.15
Ψ(.)	373.00	2.07	0.04	6	361.00
Ψ(Mesh2000)	373.44	2.51	0.03	7	359.44
Ψ(Mesh1200)	373.53	2.60	0.03	7	359.53
Ψ(Mesh1300)	373.54	2.61	0.03	7	359.54
Ψ(Mesh1100)	373.55	2.62	0.03	7	359.55
Ψ(Mesh1900)	373.58	2.64	0.03	7	359.58
Ψ(Mesh1400)	373.58	2.65	0.03	7	359.58
Ψ(Mesh1500)	373.64	2.71	0.03	7	359.64
Ψ(Mesh1600)	373.70	2.76	0.03	7	359.70
Ψ(Mesh1800)	373.71	2.78	0.03	7	359.71
Ψ(Mesh1700)	373.73	2.80	0.03	7	359.73

Appendix 2 continued.

Appendix 2.h Southern Leopard Frog Highway Density AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(.)	373.00	0.00	0.19	6	361.00
Ψ(Hwy1200)	374.24	1.24	0.10	7	360.24
Ψ(Hwy1100)	374.27	1.27	0.10	7	360.27
Ψ(Hwy1300)	374.33	1.33	0.10	7	360.33
Ψ(Hwy1400)	374.55	1.55	0.09	7	360.55
Ψ(Hwy1500)	374.67	1.67	0.08	7	360.67
Ψ(Hwy1600)	374.85	1.85	0.07	7	360.85
Ψ(Hwy1700)	374.94	1.94	0.07	7	360.94
Ψ(Hwy1800)	374.98	1.98	0.07	7	360.98
Ψ(Hwy1900)	375.00	2.00	0.07	7	361.00
Ψ(Hwy2000)	375.00	2.00	0.07	7	361.00

Appendix 2.i Southern Leopard Frog Percent Wetland Cover AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(.)	373.00	0.00	0.07	6	361.00
Ψ(Wet1400)	373.31	0.31	0.06	7	359.31
Ψ(Wet1500)	373.37	0.37	0.06	7	359.37
Ψ(Wet1300)	373.51	0.51	0.06	7	359.51
Ψ(Wet1600)	373.65	0.65	0.05	7	359.65
Ψ(WetLN1800)	373.70	0.70	0.05	7	359.70
Ψ(WetLN1500)	373.79	0.79	0.05	7	359.79
Ψ(Wet1200)	373.81	0.81	0.05	7	359.81
Ψ(WetLN1700)	373.83	0.83	0.05	7	359.83
Ψ(Wet1700)	373.85	0.85	0.05	7	359.85
Ψ(WetLN1600)	373.91	0.91	0.05	7	359.91
Ψ(Wet1800)	373.94	0.94	0.05	7	359.94
Ψ(Wet1100)	374.10	1.11	0.04	7	360.10
Ψ(WetLN1900)	374.11	1.11	0.04	7	360.11
Ψ(WetLN1400)	374.18	1.18	0.04	7	360.18
Ψ(Wet1900)	374.21	1.21	0.04	7	360.21
Ψ(WetLN1300)	374.25	1.25	0.04	7	360.25
Ψ(Wet2000)	374.36	1.36	0.04	7	360.36
Ψ(WetLN2000)	374.37	1.37	0.04	7	360.37
Ψ(WetLN1200)	374.50	1.50	0.03	7	360.50
Ψ(WetLN1100)	374.66	1.66	0.03	7	360.66

Appendix 2 continued.

Appendix 2.j Southern Leopard Frog Local Scale AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(SiteType)	372.67	0.00	0.17	7	358.67
Ψ(.)	373.00	0.33	0.15	6	361.00
Ψ(Peri,SiteType)	373.64	0.97	0.11	8	357.64
Ψ(PerCan,SiteType)	373.78	1.11	0.10	8	357.78
Ψ(Area)	374.06	1.40	0.09	7	360.06
Ψ(Area,SiteType)	374.25	1.58	0.08	8	358.25
Ψ(Peri)	374.46	1.80	0.07	7	360.46
Ψ(PerCan)	374.60	1.93	0.07	7	360.60
Ψ(PerCan,Area,SiteType)	375.02	2.35	0.05	9	357.02
Ψ(PerCan,Peri,SiteType)	375.23	2.57	0.05	9	357.23
Ψ(PerCan,Area)	375.25	2.58	0.05	8	359.25
Ψ(PerCan,Peri)	376.31	3.64	0.03	8	360.31

Appendix 2.k Southern Leopard Frog Migration Scale AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ForLN800,StrDen300)	362.69	0.00	0.57	8	346.69
Ψ(ForLN800,ForClump700,StrDen300)	364.60	1.92	0.22	9	346.60
Ψ(ForClump700,StrDen300)	366.13	3.44	0.10	8	350.13
Ψ(.)	373.00	10.31	0.00	6	361.00

Appendix 2.l Southern Leopard Frog Dispersal Scale AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Impervious2000,Wet1400,Hwy1200)	362.76	0.00	0.43	9	344.76
Ψ(Wet1400,MeshLN2000,Hwy1200)	364.57	1.81	0.17	9	346.57
Ψ(Impervious2000,Hwy1200)	364.89	2.13	0.15	8	348.89
Ψ(Impervious2000,Wet1400)	365.27	2.51	0.12	8	349.27
Ψ(MeshLN2000,Hwy1200)	367.15	4.39	0.05	8	351.15
Ψ(.)	373.00	10.24	0.00	6	361.00

Appendix 2.m Southern Leopard Frog Multi-scale Model AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(StrDen300,Impervious2000,Wet1400,Hwy1200)	358.37	0.00	0.04	10	338.37
Ψ(SiteType,StrDen300,Impervious2000,Wet1400,Hwy1200)	359.04	0.67	0.03	11	337.04

Appendix 2 continued.

Ψ(SiteType,StrDen300,Wet1400,MeshLN2000,Hwy1200)	359.10	0.73	0.03	11	337.10
Ψ(Area,StrDen300,Impervious2000,Wet1400,Hwy1200)	359.38	1.01	0.02	11	337.38
Ψ(StrDen300,Impervious2000,Wet1400)	359.48	1.11	0.02	9	341.48
Ψ(StrDen300,Wet1400,MeshLN2000,Hwy1200)	359.64	1.27	0.02	10	339.64
Ψ(SiteType,StrDen300,Impervious2000,Wet1400)	359.76	1.39	0.02	10	339.76
Ψ(StrDen300,Impervious2000,Hwy1200)	359.80	1.43	0.02	9	341.80
Ψ(PerCan,StrDen300,Impervious2000,Wet1400,Hwy1200)	359.95	1.58	0.02	11	337.95
Ψ(ForClump700,StrDen300,Impervious2000,Wet1400,Hwy1200)	360.16	1.79	0.02	11	338.16
Ψ(Peri,StrDen300,Impervious2000,Wet1400,Hwy1200)	360.33	1.95	0.02	11	338.33
Ψ(ForClump700,StrDen300,Impervious2000,Wet1400)	360.69	2.32	0.01	10	340.69
Ψ(Area,StrDen300,Impervious2000,Hwy1200)	360.74	2.37	0.01	10	340.74
Ψ(Area,StrDen300,Impervious2000,Wet1400)	360.81	2.44	0.01	10	340.81
Ψ(Area,StrDen300,Wet1400,MeshLN2000,Hwy1200)	360.86	2.48	0.01	11	338.86
Ψ(SiteType,StrDen300,Impervious2000,Hwy1200)	360.92	2.54	0.01	10	340.92
Ψ(PerCan,SiteType,StrDen300,Impervious2000,Wet1400)	360.92	2.55	0.01	11	338.92
Ψ(PerCan,StrDen300,Wet1400,MeshLN2000,Hwy1200)	360.99	2.61	0.01	11	338.99
Ψ(PerCan,SiteType,Wet1400,MeshLN2000,Hwy1200)	361.17	2.80	0.01	11	339.17
Ψ(PerCan,StrDen300,Impervious2000,Hwy1200)	361.18	2.81	0.01	10	341.18
Ψ(PerCan,StrDen300,Impervious2000,Wet1400)	361.20	2.83	0.01	10	341.20
Ψ(Peri,SiteType,StrDen300,Impervious2000,Wet1400)	361.28	2.91	0.01	11	339.28
Ψ(SiteType,ForClump700,StrDen300,Impervious2000,Wet1400)	361.31	2.93	0.01	11	339.31
Ψ(Peri,StrDen300,Impervious2000,Wet1400)	361.31	2.94	0.01	10	341.31
Ψ(Peri,StrDen300,Wet1400,MeshLN2000,Hwy1200)	361.40	3.03	0.01	11	339.40
Ψ(ForClump700,StrDen300,Wet1400,MeshLN2000,Hwy1200)	361.41	3.04	0.01	11	339.41
Ψ(Peri,StrDen300,Impervious2000,Hwy1200)	361.44	3.07	0.01	10	341.44
Ψ(Area,SiteType,StrDen300,Impervious2000,Wet1400)	361.49	3.12	0.01	11	339.49
Ψ(StrDen300,Impervious2000)	361.56	3.19	0.01	8	345.56
Ψ(SiteType,StrDen300,Wet1400,MeshLN2000)	361.57	3.19	0.01	10	341.57
Ψ(ForClump700,StrDen300,Impervious2000,Hwy1200)	361.65	3.28	0.01	10	341.65
Ψ(StrDen300,MeshLN2000,Hwy1200)	361.70	3.33	0.01	9	343.70
Ψ(PerCan,SiteType,StrDen300,Impervious2000,Hwy1200)	361.92	3.55	0.01	11	339.92
Ψ(PerCan,Area,StrDen300,Impervious2000,Hwy1200)	361.99	3.62	0.01	11	339.99
Ψ(SiteType,StrDen300,MeshLN2000,Hwy1200)	362.05	3.68	0.01	10	342.05
Ψ(SiteType,ForLN800,StrDen300,Wet1400)	362.09	3.72	0.01	10	342.09
Ψ(StrDen300,Wet1400,MeshLN2000)	362.15	3.78	0.01	9	344.15
Ψ(Area,ForClump700,StrDen300,Impervious2000,Wet1400)	362.19	3.82	0.01	11	340.19
Ψ(Area,SiteType,StrDen300,Impervious2000,Hwy1200)	362.20	3.83	0.01	11	340.20
Ψ(PerCan,ForClump700,StrDen300,Impervious2000,Wet1400)	362.26	3.89	0.01	11	340.26
Ψ(Peri,SiteType,StrDen300,Impervious2000,Hwy1200)	362.26	3.89	0.01	11	340.26

Appendix 2 continued.

Ψ(ForLN800,StrDen300,Wet1400)	362.30	3.93	0.01	9	344.30
Ψ(SiteType,StrDen300,Impervious2000)	362.36	3.99	0.01	9	344.36
Ψ(PerCan,SiteType,StrDen300,Wet1400,MeshLN2000)	362.39	4.02	0.01	11	340.39
Ψ(PerCan,Area,StrDen300,Impervious2000,Wet1400)	362.44	4.07	0.01	11	340.44
Ψ(Peri,ForClump700,StrDen300,Impervious2000,Wet1400)	362.44	4.07	0.01	11	340.44
Ψ(PerCan,SiteType,StrDen300,MeshLN2000,Hwy1200)	362.51	4.14	0.01	11	340.51
Ψ(ForLN800,StrDen300,Hwy1200)	362.57	4.20	0.01	9	344.57
Ψ(Peri,SiteType,StrDen300,Wet1400,MeshLN2000)	362.62	4.25	0.00	11	340.62
Ψ(ForLN800,StrDen300)	362.69	4.31	0.00	8	346.69
Ψ(Area,ForClump700,StrDen300,Impervious2000,Hwy1200)	362.69	4.32	0.00	11	340.69
Ψ(Area,StrDen300,MeshLN2000,Hwy1200)	362.71	4.34	0.00	10	342.71
Ψ(Impervious2000,Wet1400,Hwy1200)	362.76	4.39	0.00	9	344.76
Ψ(PerCan,SiteType,Impervious2000,Wet1400,Hwy1200)	362.80	4.42	0.00	11	340.80
Ψ(Peri,SiteType,StrDen300,MeshLN2000,Hwy1200)	362.82	4.44	0.00	11	340.82
Ψ(ForClump700,StrDen300,Impervious2000)	362.82	4.45	0.00	9	344.82
Ψ(Peri,StrDen300,Impervious2000)	362.83	4.46	0.00	9	344.83
Ψ(ForLN800,StrDen300,Wet1400,Hwy1200)	362.84	4.47	0.00	10	342.84
Ψ(ForClump700,StrDen300,Wet1400,MeshLN2000)	362.85	4.48	0.00	10	342.85
Ψ(SiteType,ForClump700,StrDen300,Wet1400,MeshLN2000)	362.85	4.48	0.00	11	340.85
Ψ(SiteType,ForClump700,StrDen300,Impervious2000,Hwy1200)	362.86	4.49	0.00	11	340.86
Ψ(Area,StrDen300,Impervious2000)	362.88	4.51	0.00	9	344.88
Ψ(SiteType,ForLN800,StrDen300,Wet1400,Hwy1200)	362.92	4.54	0.00	11	340.92
Ψ(PerCan,Peri,StrDen300,Impervious2000,Hwy1200)	362.94	4.57	0.00	11	340.94
Ψ(PerCan,ForClump700,StrDen300,Impervious2000,Hwy1200)	362.95	4.58	0.00	11	340.95
Ψ(PerCan,Impervious2000,Wet1400,Hwy1200)	362.96	4.58	0.00	10	342.96
Ψ(.)	373.00	14.63	0.00	6	361.00

Appendix 3 Spring peeper AIC model selection results for the analysis of occupancy. All candidate models within confidence set, 10% of the highest Akaike weight, are displayed, as well as the "null" model without covariates. Ψ is the occupancy probability and p is the detection probability. Covariate names followed by a numerical value indicate the covariates extent, a LN indicates a pseudo-threshold relationship, and INT indicates an interaction term was included. Covariate names are: Background Noise Index = **Noise**, Beaufort Wind Score = **Beau**, Days Since Rain = **DaysRain**, Days Since Above Average Rain of Survey Period = **DaysAvgRain**, Sky and Weather Condition = **Sky**, Time of Day = **Time**, Time since Sunset = **Sunset**, Julian Date = **Jul**, Julian Date Quadratic Term = **JulSq**, Temperature = **Temp**, Wind Speed = **Wind**, Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

Appendix 3.a Spring Peeper Survey-specific Covariates AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)p(Temp,DaysRainLN)	291.08	0.00	0.07	4	283.08
Ψ(.)p(Temp,DaysAvgRain,Sky1,Sky2thru4Com)	291.77	0.69	0.05	6	279.77
Ψ(.)p(Temp,Sunset,DaysRainLN)	291.77	0.69	0.05	5	281.77
Ψ(.)p(Temp,DaysRainLN,SunsetLN)	291.81	0.73	0.05	5	281.81
Ψ(.)p(Temp,Wind,DaysRainLN)	291.91	0.83	0.05	5	281.91
Ψ(.)p(Temp,Jul,DaysRainLN)	291.91	0.83	0.05	5	281.91
Ψ(.)p(Temp,Jul,JulSq,DaysRainLN)	292.35	1.28	0.04	6	280.35
Ψ(.)p(Temp,Sky1,Sky2thru4Com,DaysRainLN)	292.58	1.50	0.03	6	280.58
Ψ(.)p(Temp,Jul,Sunset,DaysRainLN)	292.64	1.56	0.03	6	280.64
Ψ(.)p(Temp,Wind,DaysRainLN,SunsetLN)	292.67	1.59	0.03	6	280.67
Ψ(.)p(Temp,Wind,Sunset,DaysRainLN)	292.68	1.60	0.03	6	280.68
Ψ(.)p(Temp,Jul,DaysRainLN,SunsetLN)	292.74	1.66	0.03	6	280.74
Ψ(.)p(Temp,Jul,Wind,DaysRainLN)	292.81	1.73	0.03	6	280.81
Ψ(.)p(Temp,Time,DaysRainLN)	292.92	1.84	0.03	5	282.92
Ψ(.)p(Temp,DaysRainLN,TimeLN)	293.08	2.00	0.03	5	283.08
Ψ(.)p(Temp,Jul,Time,DaysRainLN)	293.51	2.44	0.02	6	281.51
Ψ(.)p(Temp,Wind,Time,DaysRainLN)	293.75	2.67	0.02	6	281.75
Ψ(.)p(Temp,Jul,DaysRainLN,TimeLN)	293.83	2.75	0.02	6	281.83
Ψ(.)p(Temp,Wind,DaysRainLN,TimeLN)	293.90	2.83	0.02	6	281.90
Ψ(.)p(Temp,DaysAvgRain)	294.03	2.95	0.02	4	286.03
Ψ(.)p(Temp,Wind,DaysAvgRain)	294.74	3.66	0.01	5	284.74
Ψ(.)p(Temp,DaysAvgRain,SunsetLN)	294.86	3.78	0.01	5	284.86
Ψ(.)p(Temp,DaysAvgRain,Jul,JulSq)	294.87	3.79	0.01	6	282.87
Ψ(.)p(Temp,DaysAvgRain,Sunset)	294.96	3.88	0.01	5	284.96
Ψ(.)p(Temp,DaysRain,Sky1,Sky2thru4Com)	295.07	3.99	0.01	6	283.07
Ψ(.)p(Temp,Wind,DaysAvgRain,SunsetLN)	295.37	4.29	0.01	6	283.37
Ψ(.)p(Temp,DaysAvgRain,Time)	295.51	4.43	0.01	5	285.51
Ψ(.)p(Temp,Wind,DaysAvgRain,Sunset)	295.52	4.44	0.01	6	283.52

Appendix 3 continued.

Appendix 3.b Spring Peeper Percent Forest Cover AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ForLN600)	249.58	0.00	0.27	5	239.58
Ψ(ForLN500)	250.29	0.71	0.19	5	240.29
Ψ(ForLN700)	250.36	0.78	0.18	5	240.36
Ψ(ForLN400)	251.60	2.02	0.10	5	241.60
Ψ(ForLN800)	252.16	2.58	0.07	5	242.16
Ψ(ForLN900)	252.41	2.82	0.06	5	242.41
Ψ(ForLN1000)	252.70	3.12	0.06	5	242.70
Ψ(For600)	255.19	5.61	0.02	5	245.19
Ψ(ForLN300)	255.81	6.23	0.01	5	245.81
Ψ(For700)	255.83	6.25	0.01	5	245.83
Ψ(For500)	256.53	6.94	0.01	5	246.53
Ψ(For1000)	256.73	7.15	0.01	5	246.73
Ψ(For900)	256.76	7.17	0.01	5	246.76
Ψ(For800)	256.94	7.36	0.01	5	246.94
Ψ(.)	291.08	41.50	0.00	4	283.08

Appendix 3.c Spring Peeper Forest Clumpiness Index AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ForClump1000)	264.78	0.00	0.59	5	254.78
Ψ(ForClump900)	267.17	2.39	0.18	5	257.17
Ψ(ForClump700)	268.33	3.55	0.10	5	258.33
Ψ(ForClump800)	268.52	3.74	0.09	5	258.52
Ψ(.)	291.08	26.30	0.00	4	283.08

Appendix 3.d Spring Peeper Percent Forest Cover/Clumpiness Interaction AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ForLN600)	249.58	0.00	0.15	5	239.58
Ψ(ForLN500)	250.29	0.71	0.11	5	240.29
Ψ(ForLN700)	250.36	0.78	0.10	5	240.36
Ψ(ForLN600,ForClump600)	251.43	1.85	0.06	6	239.43
Ψ(ForLN400)	251.60	2.02	0.05	5	241.60
Ψ(ForLN700,ForClump700)	251.72	2.14	0.05	6	239.72
Ψ(ForLN500,ForClump500)	252.04	2.46	0.04	6	240.04

Appendix 3 continued.

Ψ(ForLN800)	252.16	2.58	0.04	5	242.16
Ψ(ForLN900)	252.41	2.82	0.04	5	242.41
Ψ(ForLN1000)	252.70	3.12	0.03	5	242.70
Ψ(ForLN700,ForClump700,ForClumpIntLN700)	253.26	3.68	0.02	7	239.26
Ψ(ForLN400,ForClump400)	253.35	3.77	0.02	6	241.35
Ψ(ForLN600,ForClump600,ForClumpIntLN600)	253.40	3.82	0.02	7	239.40
Ψ(ForLN1000,ForClump1000)	253.40	3.82	0.02	6	241.40
Ψ(ForLN900,ForClump900)	253.40	3.82	0.02	6	241.40
Ψ(ForLN800,ForClump800)	253.51	3.93	0.02	6	241.51
Ψ(ForLN500,ForClump500,ForClumpIntLN500)	254.03	4.45	0.02	7	240.03
Ψ(.)	291.08	41.50	0.00	4	283.08

Appendix 3.e Spring Peeper Stream Density AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)	291.08	0.00	0.17	4	283.08
Ψ(StrDen100)	291.62	0.54	0.13	5	281.62
Ψ(StrDen700)	291.92	0.84	0.11	5	281.92
Ψ(StrDen800)	292.30	1.23	0.09	5	282.30
Ψ(StrDen600)	292.50	1.42	0.08	5	282.50
Ψ(StrDen900)	292.55	1.47	0.08	5	282.55
Ψ(StrDen1000)	292.57	1.50	0.08	5	282.57
Ψ(StrDen500)	292.68	1.60	0.07	5	282.68
Ψ(StrDen200)	292.75	1.67	0.07	5	282.75
Ψ(StrDen400)	293.04	1.96	0.06	5	283.04
Ψ(StrDen300)	293.07	1.99	0.06	5	283.07

Appendix 3.f Spring Peeper Percent NLCD Impervious Surface AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ImperviousLN1400)	259.68	0.00	0.12	5	249.68
Ψ(ImperviousLN1500)	259.80	0.12	0.11	5	249.80
Ψ(ImperviousLN1600)	259.91	0.23	0.10	5	249.91
Ψ(ImperviousLN1300)	259.93	0.25	0.10	5	249.93
Ψ(ImperviousLN1200)	260.03	0.34	0.10	5	250.03
Ψ(ImperviousLN1100)	260.27	0.59	0.09	5	250.27
Ψ(ImperviousLN1700)	260.32	0.64	0.08	5	250.32
Ψ(ImperviousLN1900)	260.50	0.82	0.08	5	250.50
Ψ(ImperviousLN1800)	260.54	0.86	0.08	5	250.54

Appendix 3 continued.

Ψ(ImperviousLN2000)	260.85	1.17	0.06	5	250.85
Ψ(.)	291.08	31.40	0.00	4	283.08

Appendix 3.g Spring Peeper Effective Mesh Size AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Mesh1500)	255.55	0.00	0.12	5	245.55
Ψ(Mesh1600)	255.57	0.03	0.12	5	245.57
Ψ(Mesh1700)	255.64	0.09	0.11	5	245.64
Ψ(Mesh1400)	255.91	0.36	0.10	5	245.91
Ψ(Mesh1300)	256.46	0.91	0.08	5	246.46
Ψ(MeshLN1700)	256.96	1.42	0.06	5	246.96
Ψ(MeshLN1600)	257.08	1.54	0.05	5	247.08
Ψ(MeshLN1500)	257.13	1.58	0.05	5	247.13
Ψ(Mesh1200)	257.43	1.88	0.05	5	247.43
Ψ(Mesh1800)	257.49	1.95	0.04	5	247.49
Ψ(Mesh1900)	257.90	2.35	0.04	5	247.90
Ψ(MeshLN1400)	257.98	2.43	0.04	5	247.98
Ψ(Mesh1100)	258.65	3.10	0.03	5	248.65
Ψ(MeshLN1300)	258.75	3.21	0.02	5	248.75
Ψ(Mesh2000)	258.76	3.21	0.02	5	248.76
Ψ(MeshLN1800)	258.79	3.25	0.02	5	248.79
Ψ(MeshLN1900)	259.36	3.81	0.02	5	249.36
Ψ(MeshLN1200)	259.66	4.11	0.02	5	249.66
Ψ(.)	291.08	35.53	0.00	4	283.08

Appendix 3.h Spring Peeper Highway Density AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Hwy2000)	281.45	0.00	0.33	5	271.45
Ψ(Hwy1900)	282.54	1.09	0.19	5	272.54
Ψ(Hwy1800)	283.18	1.73	0.14	5	273.18
Ψ(Hwy1700)	283.92	2.47	0.10	5	273.92
Ψ(Hwy1600)	284.59	3.14	0.07	5	274.59
Ψ(Hwy1500)	285.48	4.03	0.04	5	275.48
Ψ(Hwy1400)	285.67	4.22	0.04	5	275.67
Ψ(.)	291.08	9.63	0.00	4	283.08

Appendix 3 continued.

Appendix 3.i Spring Peeper Percent Wetland Cover AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(WetLN2000)	284.69	0.00	0.25	5	274.69
Ψ(Wet2000)	286.08	1.39	0.13	5	276.08
Ψ(WetLN1900)	286.73	2.04	0.09	5	276.73
Ψ(WetLN1800)	287.38	2.69	0.07	5	277.38
Ψ(Wet1900)	287.39	2.70	0.07	5	277.39
Ψ(WetLN1700)	288.15	3.47	0.04	5	278.15
Ψ(Wet1800)	288.34	3.65	0.04	5	278.34
Ψ(WetLN1600)	288.55	3.87	0.04	5	278.55
Ψ(Wet1300)	288.60	3.91	0.04	5	278.60
Ψ(Wet1400)	288.70	4.01	0.03	5	278.70
Ψ(Wet1700)	288.78	4.09	0.03	5	278.78
Ψ(Wet1200)	288.85	4.16	0.03	5	278.85
Ψ(Wet1500)	288.98	4.29	0.03	5	278.98
Ψ(Wet1600)	289.05	4.37	0.03	5	279.05
Ψ(.)	291.08	6.39	0.01	4	283.08

Appendix 3.j Spring Peeper Local Scale AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(PerCan,SiteType)	285.60	0.00	0.22	6	273.60
Ψ(PerCan)	285.86	0.26	0.19	5	275.86
Ψ(PerCan,Area)	287.03	1.42	0.11	6	275.03
Ψ(PerCan,Area,SiteType)	287.16	1.56	0.10	7	273.16
Ψ(PerCan,Peri,SiteType)	287.21	1.61	0.10	7	273.21
Ψ(PerCan,Peri)	287.37	1.77	0.09	6	275.37
Ψ(Area,SiteType)	288.53	2.93	0.05	6	276.53
Ψ(Peri,SiteType)	289.05	3.45	0.04	6	277.05
Ψ(SiteType)	289.14	3.54	0.04	5	279.14
Ψ(Area)	289.46	3.86	0.03	5	279.46
Ψ(.)	291.08	5.48	0.01	4	283.08

Appendix 3 continued.

Appendix 3.k Spring Peeper Migration Scale AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ForLN600,ForClump1000)	249.47	0.00	0.35	6	237.47
Ψ(ForLN600)	249.58	0.11	0.33	5	239.58
Ψ(ForLN600,ForClump1000,StrDen100)	250.87	1.40	0.17	7	236.87
Ψ(ForLN600,StrDen100)	251.06	1.59	0.16	6	239.06
Ψ(.)	291.08	41.61	0.00	4	283.08

Appendix 3.l Spring Peeper Dispersal Scale AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Mesh1500)	255.55	0.00	0.41	5	245.55
Ψ(WetLN2000,Mesh1500)	256.82	1.27	0.22	6	244.82
Ψ(Mesh1500,Hwy2000)	257.47	1.92	0.16	6	245.47
Ψ(WetLN2000,Mesh1500,Hwy2000)	258.70	3.15	0.09	7	244.70
Ψ(ImperviousLN1400)	259.68	4.13	0.05	5	249.68
Ψ(.)	291.08	35.53	0.00	4	283.08

Appendix 3.m Spring Peeper Multi-scale Model AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ForLN600,ForClump1000,WetLN2000,Mesh1500)	243.49	0.00	0.03	8	227.49
Ψ(SiteType,ForLN600,ForClump1000,Mesh1500)	243.58	0.09	0.03	8	227.58
Ψ(ForLN600,ForClump1000,Mesh1500)	243.70	0.21	0.03	7	229.70
Ψ(SiteType,ForLN600,Mesh1500)	243.75	0.26	0.02	7	229.75
Ψ(PerCan,ForLN600,ForClump1000,WetLN2000,Mesh1500)	243.83	0.34	0.02	9	225.83
Ψ(ForLN600,Mesh1500)	243.90	0.41	0.02	6	231.90
Ψ(ForLN600,WetLN2000,Mesh1500)	244.04	0.55	0.02	7	230.04
Ψ(SiteType,ForLN600,ForClump1000,WetLN2000,Mesh1500)	244.30	0.81	0.02	9	226.30
Ψ(PerCan,ForLN600,ForClump1000,Mesh1500)	244.49	1.00	0.02	8	228.49
Ψ(SiteType,ForLN600,WetLN2000,Mesh1500)	244.75	1.26	0.02	8	228.75
Ψ(PerCan,ForLN600,WetLN2000,Mesh1500)	244.85	1.37	0.01	8	228.85
Ψ(PerCan,SiteType,ForLN600,ForClump1000,Mesh1500)	245.00	1.51	0.01	9	227.00
Ψ(PerCan,ForLN600,Mesh1500)	245.05	1.56	0.01	7	231.05
Ψ(Area,SiteType,ForLN600,ForClump1000,Mesh1500)	245.14	1.65	0.01	9	227.14
Ψ(PerCan,ForLN600,ForClump1000,WetLN2000)	245.29	1.80	0.01	8	229.29
Ψ(Area,SiteType,ForLN600,Mesh1500)	245.29	1.81	0.01	8	229.29
Ψ(ForLN600,ForClump1000,StrDen100,WetLN2000,Mesh1500)	245.38	1.89	0.01	9	227.38
Ψ(PerCan,SiteType,ForLN600,Mesh1500)	245.38	1.90	0.01	8	229.38

Appendix 3 continued.

Ψ(Area,ForLN600,ForClump1000,WetLN2000,Mesh1500)	245.41	1.92	0.01	9	227.41
Ψ(Peri,ForLN600,ForClump1000,WetLN2000,Mesh1500)	245.46	1.97	0.01	9	227.46
Ψ(Peri,SiteType,ForLN600,ForClump1000,Mesh1500)	245.47	1.99	0.01	9	227.47
Ψ(ForLN600,ForClump1000,WetLN2000,Mesh1500,Hwy2000)	245.48	1.99	0.01	9	227.48
Ψ(SiteType,ForLN600,Mesh1500,Hwy2000)	245.50	2.01	0.01	8	229.50
Ψ(SiteType,ForLN600,ForClump1000,StrDen100,Mesh1500)	245.53	2.04	0.01	9	227.53
Ψ(Peri,SiteType,ForLN600,Mesh1500)	245.57	2.08	0.01	8	229.57
Ψ(SiteType,ForLN600,ForClump1000,Mesh1500,Hwy2000)	245.58	2.09	0.01	9	227.58
Ψ(ForLN600,WetLN2000,Mesh1500,Hwy2000)	245.58	2.09	0.01	8	229.58
Ψ(ForLN600,Mesh1500,Hwy2000)	245.61	2.12	0.01	7	231.61
Ψ(Area,ForLN600,ForClump1000,Mesh1500)	245.62	2.13	0.01	8	229.62
Ψ(ForLN600,ForClump1000,StrDen100,Mesh1500)	245.67	2.18	0.01	8	229.67
Ψ(Peri,ForLN600,ForClump1000,Mesh1500)	245.68	2.19	0.01	8	229.68
Ψ(ForLN600,ForClump1000,Mesh1500,Hwy2000)	245.69	2.20	0.01	8	229.69
Ψ(SiteType,ForLN600,StrDen100,Mesh1500)	245.72	2.23	0.01	8	229.72
Ψ(Area,ForLN600,Mesh1500)	245.82	2.33	0.01	7	231.82
Ψ(Peri,ForLN600,Mesh1500)	245.87	2.38	0.01	7	231.87
Ψ(ForLN600,StrDen100,Mesh1500)	245.88	2.39	0.01	7	231.88
Ψ(Area,ForLN600,WetLN2000,Mesh1500)	245.97	2.49	0.01	8	229.97
Ψ(ForLN600,StrDen100,WetLN2000,Mesh1500)	245.98	2.49	0.01	8	229.98
Ψ(Peri,ForLN600,WetLN2000,Mesh1500)	245.99	2.50	0.01	8	229.99
Ψ(PerCan,SiteType,ForLN600,WetLN2000,Mesh1500)	246.04	2.56	0.01	9	228.04
Ψ(PerCan,ForLN600,WetLN2000,Mesh1500,Hwy2000)	246.30	2.82	0.01	9	228.30
Ψ(PerCan,Area,ForLN600,ForClump1000,Mesh1500)	246.32	2.84	0.01	9	228.32
Ψ(SiteType,ForLN600,WetLN2000,Mesh1500,Hwy2000)	246.33	2.84	0.01	9	228.33
Ψ(PerCan,Peri,ForLN600,ForClump1000,Mesh1500)	246.35	2.86	0.01	9	228.35
Ψ(PerCan,ForLN600,WetLN2000)	246.37	2.88	0.01	7	232.37
Ψ(Area,SiteType,ForLN600,WetLN2000,Mesh1500)	246.43	2.94	0.01	9	228.43
Ψ(PerCan,ForLN600,ForClump1000,StrDen100,Mesh1500)	246.45	2.96	0.01	9	228.45
Ψ(PerCan,ForLN600,ForClump1000,Mesh1500,Hwy2000)	246.48	2.99	0.01	9	228.48
Ψ(PerCan,Peri,ForLN600,WetLN2000,Mesh1500)	246.55	3.06	0.01	9	228.55
Ψ(Peri,SiteType,ForLN600,WetLN2000,Mesh1500)	246.58	3.09	0.01	9	228.58
Ψ(ForLN600,ForClump1000,WetLN2000)	246.62	3.13	0.01	7	232.62
Ψ(SiteType,ForLN600,StrDen100,WetLN2000,Mesh1500)	246.68	3.19	0.01	9	228.68
Ψ(PerCan,Area,ForLN600,WetLN2000,Mesh1500)	246.70	3.21	0.01	9	228.70
Ψ(PerCan,ForLN600,Mesh1500,Hwy2000)	246.74	3.25	0.01	8	230.74
Ψ(PerCan,ForLN600,ForClump1000,WetLN2000,Hwy2000)	246.81	3.32	0.01	9	228.81
Ψ(PerCan,SiteType,ForLN600,ForClump1000,WetLN2000)	246.83	3.34	0.01	9	228.83
Ψ(PerCan,ForLN600,StrDen100,WetLN2000,Mesh1500)	246.84	3.35	0.01	9	228.84

Appendix 3 continued.

Ψ(PerCan,Area,SiteType,ForLN600,Mesh1500)	246.86	3.37	0.01	9	228.86
Ψ(PerCan,Peri,ForLN600,Mesh1500)	246.87	3.38	0.01	8	230.87
Ψ(PerCan,Area,ForLN600,Mesh1500)	246.90	3.41	0.01	8	230.90
Ψ(SiteType,ForClump1000,Mesh1500)	247.01	3.52	0.00	7	233.01
Ψ(PerCan,ForLN600,StrDen100,Mesh1500)	247.02	3.53	0.00	8	231.02
Ψ(PerCan,Peri,SiteType,ForLN600,Mesh1500)	247.02	3.54	0.00	9	229.02
Ψ(ForLN600,WetLN2000)	247.07	3.59	0.00	6	235.07
Ψ(PerCan,SiteType,ForLN600,Mesh1500,Hwy2000)	247.12	3.63	0.00	9	229.12
Ψ(Area,SiteType,ForLN600,Mesh1500,Hwy2000)	247.14	3.65	0.00	9	229.14
Ψ(ForClump1000,Mesh1500)	247.17	3.68	0.00	6	235.17
Ψ(PerCan,Peri,ForLN600,ForClump1000,WetLN2000)	247.20	3.71	0.00	9	229.20
Ψ(Area,SiteType,ForLN600,StrDen100,Mesh1500)	247.25	3.76	0.00	9	229.25
Ψ(PerCan,ForLN600,ForClump1000,StrDen100,WetLN2000)	247.25	3.76	0.00	9	229.25
Ψ(PerCan,Area,ForLN600,ForClump1000,WetLN2000)	247.27	3.79	0.00	9	229.27
Ψ(Peri,SiteType,ForLN600,Mesh1500,Hwy2000)	247.38	3.89	0.00	9	229.38
Ψ(PerCan,SiteType,ForLN600,StrDen100,Mesh1500)	247.38	3.90	0.00	9	229.38
Ψ(ForClump1000,WetLN2000,Mesh1500)	247.40	3.91	0.00	7	233.40
Ψ(SiteType,ForLN600,StrDen100,Mesh1500,Hwy2000)	247.47	3.98	0.00	9	229.47
Ψ(Peri,SiteType,ForLN600,StrDen100,Mesh1500)	247.47	3.98	0.00	9	229.47
Ψ(ForLN600,StrDen100,WetLN2000,Mesh1500,Hwy2000)	247.52	4.03	0.00	9	229.52
Ψ(Area,ForLN600,WetLN2000,Mesh1500,Hwy2000)	247.55	4.06	0.00	9	229.55
Ψ(Peri,ForLN600,WetLN2000,Mesh1500,Hwy2000)	247.56	4.07	0.00	9	229.56
Ψ(Area,ForLN600,Mesh1500,Hwy2000)	247.57	4.08	0.00	8	231.57
Ψ(Area,ForLN600,ForClump1000,StrDen100,Mesh1500)	247.59	4.10	0.00	9	229.59
Ψ(ForLN600,StrDen100,Mesh1500,Hwy2000)	247.60	4.11	0.00	8	231.60
Ψ(Peri,ForLN600,Mesh1500,Hwy2000)	247.60	4.11	0.00	8	231.60
Ψ(Area,ForLN600,ForClump1000,Mesh1500,Hwy2000)	247.61	4.12	0.00	9	229.61
Ψ(ForLN600,ForClump1000,WetLN2000,Hwy2000)	247.64	4.15	0.00	8	231.64
Ψ(Peri,ForLN600,ForClump1000,StrDen100,Mesh1500)	247.65	4.16	0.00	9	229.65
Ψ(SiteType,ForLN600,ForClump1000,WetLN2000)	247.65	4.17	0.00	8	231.65
Ψ(ForLN600,ForClump1000,StrDen100,Mesh1500,Hwy2000)	247.67	4.18	0.00	9	229.67
Ψ(Peri,ForLN600,ForClump1000,Mesh1500,Hwy2000)	247.68	4.19	0.00	9	229.68
Ψ(PerCan,SiteType,ForLN600,WetLN2000)	247.75	4.26	0.00	8	231.75
Ψ(Area,ForLN600,StrDen100,Mesh1500)	247.80	4.31	0.00	8	231.80
Ψ(Peri,ForLN600,StrDen100,Mesh1500)	247.84	4.35	0.00	8	231.84
Ψ(PerCan,ForClump1000,WetLN2000,Mesh1500)	247.85	4.36	0.00	8	231.85
Ψ(PerCan,ForClump1000,Mesh1500)	247.87	4.38	0.00	7	233.87
Ψ(Peri,ForLN600,StrDen100,WetLN2000,Mesh1500)	247.88	4.39	0.00	9	229.88
Ψ(Area,ForLN600,StrDen100,WetLN2000,Mesh1500)	247.91	4.42	0.00	9	229.91
Ψ(SiteType,ForClump1000,WetLN2000,Mesh1500)	247.98	4.49	0.00	8	231.98

Appendix 3 continued.

Ψ(ForLN600,ForClump1000,StrDen100,WetLN2000)	247.99	4.50	0.00	8	231.99
Ψ(SiteType,ForLN600,WetLN2000)	248.00	4.51	0.00	7	234.00
Ψ(.)	291.08	47.59	0.00	4	283.08

Appendix 4 American bullfrog AIC model selection results for the analysis of occupancy. All candidate models within confidence set, 10% of the highest Akaike weight, are displayed, as well as the "null" model without covariates. Ψ is the occupancy probability and p is the detection probability. Covariate names followed by a numerical value indicate the covariates extent, a LN indicates a pseudo-threshold relationship, and INT indicates an interaction term was included. Covariate names are: Background Noise Index = **Noise**, Beaufort Wind Score = **Beau**, Days Since Rain = **DaysRain**, Days Since Above Average Rain of Survey Period = **DaysAvgRain**, Sky and Weather Condition = **Sky**, Time of Day = **Time**, Time since Sunset = **Sunset**, Julian Date = **Jul**, Julian Date Quadratic Term = **JulSq**, Temperature = **Temp**, Wind Speed = **Wind**, Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

Appendix 4.a American Bullfrog Survey-specific Covariates AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)p(DaysAvgRain,Jul,JulSq,SunsetLN)	748.41	0.00	0.30	6	736.41
Ψ(.)p(DaysAvgRain,Jul,JulSq,TimeLN)	751.17	2.76	0.07	6	739.17
Ψ(.)p(Wind,Jul,JulSq,SunsetLN)	751.24	2.83	0.07	6	739.24
Ψ(.)p(Jul,JulSq,SunsetLN)	751.53	3.12	0.06	5	741.53
Ψ(.)p(Temp,Jul,JulSq,SunsetLN)	751.59	3.17	0.06	6	739.59
Ψ(.)p(DaysAvgRain,Sunset,Jul,JulSq)	752.53	4.12	0.04	6	740.53
Ψ(.)p(DaysRain,Jul,JulSq,SunsetLN)	752.59	4.17	0.04	6	740.59
Ψ(.)p(DaysAvgRain,Time,Jul,JulSq)	752.60	4.19	0.04	6	740.60

Appendix 4.b American Bullfrog Percent Forest Cover AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)	748.41	0.00	0.07	6	736.41
Ψ(ForLN200)	748.50	0.09	0.07	7	734.50
Ψ(ForLN300)	748.77	0.36	0.06	7	734.77
Ψ(For200)	749.06	0.64	0.05	7	735.06
Ψ(ForLN400)	749.10	0.69	0.05	7	735.10
Ψ(ForLN500)	749.20	0.79	0.05	7	735.20
Ψ(ForLN100)	749.22	0.81	0.05	7	735.22
Ψ(ForLN700)	749.23	0.81	0.05	7	735.23
Ψ(ForLN800)	749.23	0.82	0.05	7	735.23

Appendix 4 continued.

Ψ(ForLN900)	749.25	0.84	0.05	7	735.25
Ψ(ForLN600)	749.26	0.84	0.05	7	735.26
Ψ(ForLN1000)	749.27	0.86	0.05	7	735.27
Ψ(For700)	749.29	0.88	0.04	7	735.29
Ψ(For800)	749.30	0.89	0.04	7	735.30
Ψ(For900)	749.32	0.91	0.04	7	735.32
Ψ(For400)	749.34	0.92	0.04	7	735.34
Ψ(For500)	749.41	1.00	0.04	7	735.41
Ψ(For1000)	749.43	1.01	0.04	7	735.43
Ψ(For600)	749.44	1.02	0.04	7	735.44
Ψ(For300)	749.48	1.06	0.04	7	735.48
Ψ(For100)	749.61	1.19	0.04	7	735.61

Appendix 4.c American Bullfrog Forest Clumpiness Index AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)	748.41	0.00	0.20	6	736.41
Ψ(ForClump200)	750.11	1.70	0.09	7	736.11
Ψ(ForClump100)	750.18	1.77	0.08	7	736.18
Ψ(ForClump700)	750.19	1.78	0.08	7	736.19
Ψ(ForClump600)	750.19	1.78	0.08	7	736.19
Ψ(ForClump800)	750.26	1.85	0.08	7	736.26
Ψ(ForClump300)	750.29	1.87	0.08	7	736.29
Ψ(ForClump400)	750.30	1.89	0.08	7	736.30
Ψ(ForClump900)	750.30	1.89	0.08	7	736.30
Ψ(ForClump1000)	750.32	1.90	0.08	7	736.32
Ψ(ForClump500)	750.32	1.90	0.08	7	736.32

Appendix 4.d American Bullfrog Percent Forest Cover/Clumpiness Interaction AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)	748.41	0.00	0.04	6	736.41
Ψ(ForLN200)	748.50	0.09	0.04	7	734.50
Ψ(ForLN300)	748.77	0.36	0.03	7	734.77
Ψ(For200)	749.06	0.64	0.03	7	735.06
Ψ(ForLN400)	749.10	0.69	0.03	7	735.10
Ψ(ForLN500)	749.20	0.79	0.03	7	735.20
Ψ(ForLN100)	749.22	0.81	0.03	7	735.22
Ψ(ForLN700)	749.23	0.81	0.03	7	735.23

Appendix 4 continued.

Ψ(ForLN800)	749.23	0.82	0.02	7	735.23
Ψ(ForLN900)	749.25	0.84	0.02	7	735.25
Ψ(ForLN600)	749.26	0.84	0.02	7	735.26
Ψ(ForLN1000)	749.27	0.86	0.02	7	735.27
Ψ(For700)	749.29	0.88	0.02	7	735.29
Ψ(For800)	749.30	0.89	0.02	7	735.30
Ψ(For900)	749.32	0.91	0.02	7	735.32
Ψ(For400)	749.34	0.92	0.02	7	735.34
Ψ(For500)	749.41	1.00	0.02	7	735.41
Ψ(For1000)	749.43	1.01	0.02	7	735.43
Ψ(For600)	749.44	1.02	0.02	7	735.44
Ψ(For300)	749.48	1.06	0.02	7	735.48
Ψ(For100)	749.61	1.19	0.02	7	735.61
Ψ(ForLN100,ForClump100)	749.93	1.52	0.02	8	733.93
Ψ(ForClump200)	750.11	1.70	0.02	7	736.11
Ψ(ForClump100)	750.18	1.77	0.02	7	736.18
Ψ(ForClump700)	750.19	1.78	0.02	7	736.19
Ψ(ForClump600)	750.19	1.78	0.02	7	736.19
Ψ(ForClump800)	750.26	1.85	0.01	7	736.26
Ψ(ForClump300)	750.29	1.87	0.01	7	736.29
Ψ(ForClump400)	750.30	1.89	0.01	7	736.30
Ψ(ForClump900)	750.30	1.89	0.01	7	736.30
Ψ(ForClump1000)	750.32	1.90	0.01	7	736.32
Ψ(ForClump500)	750.32	1.90	0.01	7	736.32
Ψ(ForLN300,ForClump300)	750.43	2.02	0.01	8	734.43
Ψ(ForLN200,ForClump200)	750.48	2.07	0.01	8	734.48
Ψ(ForLN100,ForClump100,ForClumpINTLN100)	750.70	2.29	0.01	9	732.70
Ψ(ForLN1000,ForClump1000)	750.73	2.32	0.01	8	734.73
Ψ(For100,ForClump100)	750.81	2.40	0.01	8	734.81
Ψ(ForLN400,ForClump400)	750.83	2.42	0.01	8	734.83
Ψ(ForLN900,ForClump900)	750.85	2.43	0.01	8	734.85
Ψ(ForLN500,ForClump500)	750.86	2.45	0.01	8	734.86
Ψ(ForLN800,ForClump800)	750.91	2.50	0.01	8	734.91
Ψ(For200,ForClump200)	751.00	2.59	0.01	8	735.00
Ψ(ForLN700,ForClump700)	751.06	2.65	0.01	8	735.06
Ψ(ForLN600,ForClump600)	751.10	2.69	0.01	8	735.10
Ψ(For900,ForClump900)	751.11	2.70	0.01	8	735.11
Ψ(For800,ForClump800)	751.16	2.75	0.01	8	735.16
Ψ(For1000,ForClump1000)	751.19	2.78	0.01	8	735.19

Appendix 4 continued.

Ψ(For700,ForClump700)	751.24	2.83	0.01	8	735.24
Ψ(For400,ForClump400)	751.32	2.91	0.01	8	735.32
Ψ(For500,ForClump500)	751.38	2.97	0.01	8	735.38
Ψ(For600,ForClump600)	751.42	3.00	0.01	8	735.42
Ψ(For300,ForClump300)	751.47	3.06	0.01	8	735.47
Ψ(For100,ForClump100,ForClumpINT100)	751.55	3.14	0.01	9	733.55
Ψ(ForLN300,ForClump300,ForClumpINTLN300)	751.98	3.57	0.01	9	733.98
Ψ(ForLN400,ForClump400,ForClumpINTLN400)	752.47	4.05	0.00	9	734.47
Ψ(ForLN200,ForClump200,ForClumpINTLN200)	752.48	4.06	0.00	9	734.48
Ψ(ForLN1000,ForClump1000,ForClumpINTLN1000)	752.61	4.20	0.00	9	734.61
Ψ(For1000,ForClump1000,ForClumpINT1000)	752.62	4.21	0.00	9	734.62
Ψ(For900,ForClump900,ForClumpINT900)	752.77	4.36	0.00	9	734.77
Ψ(ForLN900,ForClump900,ForClumpINTLN900)	752.78	4.37	0.00	9	734.78
Ψ(ForLN500,ForClump500,ForClumpINTLN500)	752.79	4.37	0.00	9	734.79
Ψ(For400,ForClump400,ForClumpINT400)	752.79	4.38	0.00	9	734.79
Ψ(ForLN800,ForClump800,ForClumpINTLN800)	752.91	4.50	0.00	9	734.91
Ψ(For200,ForClump200,ForClumpINT200)	752.94	4.53	0.00	9	734.94
Ψ(For300,ForClump300,ForClumpINT300)	753.01	4.60	0.00	9	735.01

Appendix 4.e American Bullfrog Stream Density AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(StrDen1000)	747.05	0.00	0.14	7	733.05
Ψ(StrDen700)	747.39	0.34	0.12	7	733.39
Ψ(StrDen600)	747.40	0.35	0.12	7	733.40
Ψ(StrDen500)	747.51	0.46	0.11	7	733.51
Ψ(StrDen900)	747.56	0.51	0.11	7	733.56
Ψ(StrDen800)	747.57	0.52	0.11	7	733.57
Ψ(StrDen400)	748.17	1.12	0.08	7	734.17
Ψ(.)	748.41	1.36	0.07	6	736.41
Ψ(StrDen300)	749.29	2.24	0.05	7	735.29
Ψ(StrDen200)	749.62	2.57	0.04	7	735.62
Ψ(StrDen100)	749.68	2.63	0.04	7	735.68

Appendix 4.f American Bullfrog Percent NLCD Impervious Surface AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(Impervious1200)	747.09	0.00	0.09	7	733.09
Ψ(Impervious1300)	747.13	0.04	0.09	7	733.13

Appendix 4 continued.

Ψ(Impervious1100)	747.20	0.11	0.09	7	733.20
Ψ(Impervious1400)	747.23	0.13	0.09	7	733.23
Ψ(Impervious1500)	747.44	0.34	0.08	7	733.44
Ψ(Impervious1600)	747.67	0.58	0.07	7	733.67
Ψ(Impervious1700)	747.85	0.76	0.06	7	733.85
Ψ(Impervious1800)	748.06	0.97	0.06	7	734.06
Ψ(Impervious1900)	748.24	1.15	0.05	7	734.24
Ψ(.)	748.41	1.32	0.05	6	736.41
Ψ(Impervious2000)	748.48	1.39	0.05	7	734.48
Ψ(ImperviousLN1300)	749.74	2.65	0.02	7	735.74
Ψ(ImperviousLN1200)	749.74	2.65	0.02	7	735.74
Ψ(ImperviousLN1400)	749.74	2.65	0.02	7	735.74
Ψ(ImperviousLN1100)	749.75	2.66	0.02	7	735.75
Ψ(ImperviousLN1500)	749.76	2.67	0.02	7	735.76
Ψ(ImperviousLN1600)	749.84	2.75	0.02	7	735.84
Ψ(ImperviousLN1700)	749.93	2.84	0.02	7	735.93
Ψ(ImperviousLN1800)	750.02	2.93	0.02	7	736.02
Ψ(ImperviousLN1900)	750.09	2.99	0.02	7	736.09
Ψ(ImperviousLN2000)	750.15	3.06	0.02	7	736.15

Appendix 4.g American Bullfrog Effective Mesh Size AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(MeshLN1300)	745.21	0.00	0.09	7	731.21
Ψ(MeshLN1400)	745.25	0.04	0.08	7	731.25
Ψ(MeshLN1200)	745.27	0.06	0.08	7	731.27
Ψ(MeshLN1100)	745.36	0.14	0.08	7	731.36
Ψ(MeshLN1500)	745.55	0.34	0.07	7	731.55
Ψ(MeshLN1600)	745.88	0.67	0.06	7	731.88
Ψ(MeshLN1700)	746.30	1.09	0.05	7	732.30
Ψ(Mesh1300)	746.43	1.22	0.05	7	732.43
Ψ(Mesh1400)	746.43	1.22	0.05	7	732.43
Ψ(Mesh1200)	746.52	1.31	0.04	7	732.52
Ψ(Mesh1100)	746.59	1.38	0.04	7	732.59
Ψ(Mesh1500)	746.61	1.40	0.04	7	732.61
Ψ(MeshLN1800)	746.81	1.60	0.04	7	732.81
Ψ(Mesh1600)	746.84	1.62	0.04	7	732.84
Ψ(MeshLN1900)	747.02	1.80	0.03	7	733.02
Ψ(Mesh1700)	747.14	1.93	0.03	7	733.14

Appendix 4 continued.

Ψ(MeshLN2000)	747.38	2.17	0.03	7	733.38
Ψ(Mesh1800)	747.50	2.29	0.03	7	733.50
Ψ(Mesh1900)	747.71	2.50	0.02	7	733.71
Ψ(Mesh2000)	747.98	2.77	0.02	7	733.98
Ψ(.)	748.41	3.20	0.02	6	736.41

Appendix 4.h American Bullfrog Highway Density AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)	748.41	0.00	0.20	6	736.41
Ψ(Hwy1400)	750.13	1.72	0.09	7	736.13
Ψ(Hwy1200)	750.20	1.79	0.08	7	736.20
Ψ(Hwy1500)	750.21	1.79	0.08	7	736.21
Ψ(Hwy1300)	750.22	1.81	0.08	7	736.22
Ψ(Hwy1100)	750.29	1.87	0.08	7	736.29
Ψ(Hwy1600)	750.29	1.88	0.08	7	736.29
Ψ(Hwy1700)	750.32	1.91	0.08	7	736.32
Ψ(Hwy1800)	750.33	1.92	0.08	7	736.33
Ψ(Hwy1900)	750.36	1.95	0.08	7	736.36
Ψ(Hwy2000)	750.41	2.00	0.07	7	736.41

Appendix 4.i American Bullfrog Percent Wetland Cover AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(WetLN1100)	747.91	0.00	0.07	7	733.91
Ψ(WetLN1400)	747.99	0.08	0.07	7	733.99
Ψ(WetLN1200)	748.01	0.10	0.07	7	734.01
Ψ(WetLN1500)	748.24	0.33	0.06	7	734.24
Ψ(Wet1100)	748.38	0.47	0.05	7	734.38
Ψ(.)	748.41	0.50	0.05	6	736.41
Ψ(WetLN1300)	748.43	0.52	0.05	7	734.43
Ψ(WetLN1600)	748.52	0.61	0.05	7	734.52
Ψ(WetLN2000)	748.54	0.63	0.05	7	734.54
Ψ(WetLN1900)	748.59	0.68	0.05	7	734.59
Ψ(Wet1200)	748.64	0.73	0.05	7	734.64
Ψ(WetLN1800)	748.72	0.81	0.05	7	734.72
Ψ(WetLN1700)	748.86	0.95	0.04	7	734.86
Ψ(Wet1300)	748.88	0.97	0.04	7	734.88
Ψ(Wet1400)	749.07	1.16	0.04	7	735.07

Appendix 4 continued.

Ψ(Wet2000)	749.08	1.17	0.04	7	735.08
Ψ(Wet1900)	749.26	1.35	0.04	7	735.26
Ψ(Wet1500)	749.27	1.36	0.04	7	735.27
Ψ(Wet1800)	749.34	1.43	0.03	7	735.34
Ψ(Wet1600)	749.35	1.44	0.03	7	735.35
Ψ(Wet1700)	749.41	1.50	0.03	7	735.41

Appendix 4.j American Bullfrog Local Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(SiteType)	744.92	0.00	0.20	7	730.92
Ψ(Area,SiteType)	745.07	0.15	0.18	8	729.07
Ψ(PerCan,Area,SiteType)	745.45	0.54	0.15	9	727.45
Ψ(PerCan,SiteType)	745.98	1.07	0.12	8	729.98
Ψ(Peri,SiteType)	746.21	1.30	0.10	8	730.21
Ψ(PerCan,Peri,SiteType)	746.55	1.64	0.09	9	728.55
Ψ(PerCan)	748.16	3.25	0.04	7	734.16
Ψ(.)	748.41	3.50	0.03	6	736.41
Ψ(PerCan,Area)	748.89	3.97	0.03	8	732.89
Ψ(PerCan,Peri)	749.10	4.18	0.02	8	733.10

Appendix 4.k American Bullfrog Migration Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForLN200,StrDen1000)	747.04	0.00	0.24	8	731.04
Ψ(StrDen1000)	747.05	0.01	0.24	7	733.05
Ψ(.)	748.41	1.37	0.12	6	736.41
Ψ(ForLN200)	748.50	1.46	0.12	7	734.50
Ψ(ForClump200,StrDen1000)	748.64	1.60	0.11	8	732.64
Ψ(ForLN200,ForClump200,StrDen1000)	749.03	1.99	0.09	9	731.03
Ψ(ForClump200)	750.11	3.07	0.05	7	736.11
Ψ(ForLN200,ForClump200)	750.48	3.44	0.04	8	734.48

Appendix 4.l American Bullfrog Dispersal Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(MeshLN1300)	745.21	0.00	0.25	7	731.21
Ψ(MeshLN1300,Hwy1400)	746.36	1.15	0.14	8	730.36
Ψ(WetLN1100,MeshLN1300)	746.48	1.27	0.13	8	730.48

Appendix 4 continued.

Ψ(Impervious1200)	747.09	1.88	0.10	7	733.09
Ψ(WetLN1100,MeshLN1300,Hwy1400)	747.58	2.37	0.08	9	729.58
Ψ(Impervious1200,WetLN1100)	747.84	2.63	0.07	8	731.84
Ψ(WetLN1100)	747.91	2.70	0.07	7	733.91
Ψ(.)	748.41	3.20	0.05	6	736.41
Ψ(Impervious1200,Hwy1400)	749.00	3.79	0.04	8	733.00
Ψ(Impervious1200,WetLN1100,Hwy1400)	749.66	4.45	0.03	9	731.66
Ψ(WetLN1100,Hwy1400)	749.85	4.64	0.02	8	733.85
Ψ(Hwy1400)	750.13	4.92	0.02	7	736.13

Appendix 4.m American Bullfrog Multi-scale Model AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(Area,SiteType,StrDen1000,MeshLN1300)	737.32	0.00	0.07	10	717.32
Ψ(Peri,SiteType,StrDen1000,MeshLN1300)	738.23	0.91	0.04	10	718.23
Ψ(Area,SiteType,StrDen1000,MeshLN1300,Hwy1400)	738.88	1.56	0.03	11	716.88
Ψ(Area,SiteType,StrDen1000,WetLN1100,MeshLN1300)	739.02	1.69	0.03	11	717.02
Ψ(PerCan,Area,SiteType,StrDen1000,MeshLN1300)	739.09	1.77	0.03	11	717.09
Ψ(Area,SiteType,ForClump200,StrDen1000,MeshLN1300)	739.32	2.00	0.02	11	717.32
Ψ(Area,SiteType,ForLN200,StrDen1000,MeshLN1300)	739.32	2.00	0.02	11	717.32
Ψ(Area,SiteType,MeshLN1300)	739.38	2.06	0.02	9	721.38
Ψ(Peri,SiteType,StrDen1000,WetLN1100,MeshLN1300)	739.61	2.29	0.02	11	717.61
Ψ(Peri,SiteType,StrDen1000,MeshLN1300,Hwy1400)	739.67	2.35	0.02	11	717.67
Ψ(PerCan,Peri,SiteType,StrDen1000,MeshLN1300)	740.10	2.77	0.02	11	718.10
Ψ(Peri,SiteType,ForLN200,StrDen1000,MeshLN1300)	740.22	2.89	0.02	11	718.22
Ψ(Peri,SiteType,ForClump200,StrDen1000,MeshLN1300)	740.23	2.91	0.02	11	718.23
Ψ(Area,SiteType,WetLN1100,MeshLN1300)	740.50	3.17	0.01	10	720.50
Ψ(PerCan,Area,SiteType,MeshLN1300)	740.54	3.21	0.01	10	720.54
Ψ(Area,SiteType,StrDen1000,Impervious1200)	740.71	3.39	0.01	10	720.71
Ψ(Area,SiteType,MeshLN1300,Hwy1400)	741.19	3.87	0.01	10	721.19
Ψ(Area,SiteType,ForClump200,MeshLN1300)	741.35	4.03	0.01	10	721.35
Ψ(Area,SiteType,ForLN200,MeshLN1300)	741.37	4.05	0.01	10	721.37
Ψ(Area,SiteType,ForLN200,StrDen1000)	741.49	4.17	0.01	10	721.49
Ψ(Peri,SiteType,MeshLN1300)	741.51	4.19	0.01	9	723.51
Ψ(SiteType,StrDen1000,MeshLN1300)	741.74	4.42	0.01	9	723.74
Ψ(Peri,SiteType,StrDen1000,Impervious1200)	741.79	4.47	0.01	10	721.79
Ψ(PerCan,Area,SiteType,WetLN1100,MeshLN1300)	741.81	4.49	0.01	11	719.81
Ψ(Area,SiteType,StrDen1000)	741.88	4.56	0.01	9	723.88
Ψ(.)	748.41	11.09	0.00	6	736.41

Appendix 5 Cope's Gray Treefrog AIC model selection results for the analysis of occupancy. All candidate models within confidence set, 10% of the highest Akaike weight, are displayed, as well as the "null" model without covariates. Ψ is the occupancy probability and p is the detection probability. Covariate names followed by a numerical value indicate the covariates extent, a LN indicates a pseudo-threshold relationship, and INT indicates an interaction term was included. Covariate names are: Background Noise Index = **Noise**, Beaufort Wind Score = **Beau**, Days Since Rain = **DaysRain**, Days Since Above Average Rain of Survey Period = **DaysAvgRain**, Sky and Weather Condition = **Sky**, Time of Day = **Time**, Time since Sunset = **Sunset**, Julian Date = **Jul**, Julian Date Quadratic Term = **JulSq**, Temperature = **Temp**, Wind Speed = **Wind**, Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

Appendix 5.a Cope's Gray Treefrog Survey-specific Covariates AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)p(Temp,Jul,JulSq,SunsetLN)	652.05	0.00	0.14	6	640.05
Ψ(.)p(Temp,Jul,DaysAvgRainLN,SunsetLN)	652.88	0.82	0.09	6	640.88
Ψ(.)p(Temp,Jul,DaysAvgRainLN,TimeLN)	653.69	1.64	0.06	6	641.69
Ψ(.)p(Temp,Jul,JulSq,TimeLN)	654.04	1.99	0.05	6	642.04
Ψ(.)p(Temp,Jul,Time,DaysAvgRainLN)	654.19	2.13	0.05	6	642.19
Ψ(.)p(Temp,Jul,DaysAvgRain,SunsetLN)	654.49	2.43	0.04	6	642.49
Ψ(.)p(Temp,Sunset,Jul,JulSq)	654.50	2.45	0.04	6	642.50
Ψ(.)p(Temp,Jul,DaysRainLN,SunsetLN)	654.51	2.46	0.04	6	642.51
Ψ(.)p(Temp,Jul,SunsetLN)	654.53	2.48	0.04	5	644.53
Ψ(.)p(Temp,Time,Jul,JulSq)	654.56	2.51	0.04	6	642.56
Ψ(.)p(Temp,Jul,Sunset,DaysAvgRainLN)	654.65	2.60	0.04	6	642.65
Ψ(.)p(Temp,Jul,DaysAvgRain,TimeLN)	655.50	3.44	0.03	6	643.50
Ψ(.)p(Temp,Jul,TimeLN)	655.56	3.51	0.02	5	645.56
Ψ(.)p(Temp,Jul,Wind,SunsetLN)	655.62	3.57	0.02	6	643.62
Ψ(.)p(Temp,Jul,DaysRainLN,TimeLN)	655.75	3.70	0.02	6	643.75
Ψ(.)p(Temp,Jul,DaysRain,SunsetLN)	655.89	3.84	0.02	6	643.89
Ψ(.)p(Temp,Jul,DaysAvgRain,Time)	656.12	4.07	0.02	6	644.12
Ψ(.)p(Temp,Jul,Time)	656.13	4.08	0.02	5	646.13
Ψ(.)p(Temp,Jul,Time,DaysRainLN)	656.35	4.30	0.02	6	644.35
Ψ(.)p(Temp,Jul,Sunset)	656.57	4.52	0.01	5	646.57
Ψ(.)p(Temp,Jul,DaysAvgRain,Sunset)	656.62	4.56	0.01	6	644.62

Appendix 5.b Cope's Gray Treefrog Percent Forest Cover AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForLN1000)	620.26	0.00	0.47	7	606.26

Appendix 5 continued.

Ψ(ForLN900)	621.68	1.41	0.23	7	607.68
Ψ(ForLN800)	623.34	3.08	0.10	7	609.34
Ψ(For1000)	624.44	4.18	0.06	7	610.44
Ψ(.)	652.05	31.79	0.00	6	640.05

Appendix 5.c Cope's Gray Treefrog Forest Clumpiness Index AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForClump1000)	630.59	0.00	0.40	7	616.59
Ψ(ForClump900)	630.91	0.32	0.34	7	616.91
Ψ(ForClump800)	632.64	2.06	0.14	7	618.64
Ψ(ForClump700)	634.25	3.66	0.06	7	620.25
Ψ(.)	652.05	21.46	0.00	6	640.05

Appendix 5.d Cope's Gray Treefrog Percent Forest Cover/Clumpiness Interaction AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForLN1000)	620.26	0.00	0.26	7	606.26
Ψ(ForLN900)	621.68	1.41	0.13	7	607.68
Ψ(ForLN1000,ForClump1000)	621.74	1.48	0.12	8	605.74
Ψ(ForLN900,ForClump900)	622.71	2.45	0.08	8	606.71
Ψ(ForLN800)	623.34	3.08	0.06	7	609.34
Ψ(ForLN1000,ForClump1000,ForClumpINTLN1000)	623.73	3.47	0.05	9	605.73
Ψ(For1000)	624.44	4.18	0.03	7	610.44
Ψ(For1000,ForClump1000)	624.60	4.34	0.03	8	608.60
Ψ(ForLN800,ForClump800)	624.63	4.37	0.03	8	608.63
Ψ(ForLN900,ForClump900,ForClumpINTLN900)	624.68	4.42	0.03	9	606.68
Ψ(.)	652.05	31.79	0.00	6	640.05

Appendix 5.e Cope's Gray Treefrog Stream Density AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)	652.05	0.00	0.21	6	640.05
Ψ(StrDen100)	653.61	1.56	0.09	7	639.61
Ψ(StrDen1000)	653.91	1.86	0.08	7	639.91
Ψ(StrDen200)	653.97	1.92	0.08	7	639.97
Ψ(StrDen900)	653.98	1.93	0.08	7	639.98
Ψ(StrDen600)	654.00	1.95	0.08	7	640.00
Ψ(StrDen300)	654.02	1.97	0.08	7	640.02

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Ψ(StrDen400)	654.03	1.98	0.08	7	640.03
Ψ(StrDen700)	654.04	1.99	0.08	7	640.04
Ψ(StrDen500)	654.05	1.99	0.08	7	640.05
Ψ(StrDen800)	654.05	2.00	0.08	7	640.05

Appendix 5.f Cope's Gray Treefrog Percent Impervious Impervious Surface AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(Impervious2000)	622.83	0.00	0.16	7	608.83
Ψ(Impervious1900)	622.98	0.15	0.15	7	608.98
Ψ(Impervious1800)	623.12	0.29	0.14	7	609.12
Ψ(Impervious1700)	623.30	0.47	0.13	7	609.30
Ψ(Impervious1600)	623.59	0.77	0.11	7	609.59
Ψ(Impervious1500)	624.15	1.32	0.08	7	610.15
Ψ(Impervious1400)	624.52	1.70	0.07	7	610.52
Ψ(Impervious1300)	625.08	2.25	0.05	7	611.08
Ψ(Impervious1200)	625.91	3.09	0.04	7	611.91
Ψ(Impervious1100)	626.95	4.13	0.02	7	612.95
Ψ(.)	652.05	29.23	0.00	6	640.05

Appendix 5.g Cope's Gray Treefrog Effective Mesh Size AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(MeshLN1700)	637.73	0.00	0.15	7	623.73
Ψ(MeshLN1600)	638.11	0.38	0.12	7	624.11
Ψ(MeshLN1800)	638.41	0.69	0.11	7	624.41
Ψ(MeshLN1500)	638.44	0.71	0.10	7	624.44
Ψ(MeshLN1900)	638.45	0.73	0.10	7	624.45
Ψ(MeshLN2000)	638.78	1.05	0.09	7	624.78
Ψ(MeshLN1400)	639.11	1.38	0.07	7	625.11
Ψ(MeshLN1300)	639.88	2.16	0.05	7	625.88
Ψ(MeshLN1200)	640.81	3.08	0.03	7	626.81
Ψ(Mesh1500)	641.76	4.03	0.02	7	627.76
Ψ(Mesh1400)	641.86	4.13	0.02	7	627.86
Ψ(Mesh1600)	641.86	4.14	0.02	7	627.86
Ψ(Mesh1700)	641.91	4.18	0.02	7	627.91
Ψ(MeshLN1100)	641.95	4.22	0.02	7	627.95
Ψ(Mesh1300)	642.06	4.33	0.02	7	628.06
Ψ(.)	652.05	14.32	0.00	6	640.05

Appendix 5 continued.

Appendix 5.h Cope's Gray Treefrog Highway Density AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Hwy2000)	650.37	0.00	0.18	7	636.37
Ψ(Hwy1900)	651.29	0.92	0.12	7	637.29
Ψ(Hwy1800)	651.39	1.02	0.11	7	637.39
Ψ(Hwy1700)	651.49	1.13	0.10	7	637.49
Ψ(Hwy1600)	651.92	1.55	0.08	7	637.92
Ψ(.)	652.05	1.69	0.08	6	640.05
Ψ(Hwy1200)	652.30	1.94	0.07	7	638.30
Ψ(Hwy1100)	652.32	1.95	0.07	7	638.32
Ψ(Hwy1500)	652.43	2.06	0.07	7	638.43
Ψ(Hwy1400)	652.46	2.10	0.06	7	638.46
Ψ(Hwy1300)	652.62	2.25	0.06	7	638.62

Appendix 5.i Cope's Gray Treefrog Percent Wetland Cover AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(WetLN2000)	648.23	0.00	0.21	7	634.23
Ψ(WetLN1900)	649.87	1.64	0.09	7	635.87
Ψ(WetLN1800)	650.35	2.12	0.07	7	636.35
Ψ(Wet2000)	650.50	2.28	0.07	7	636.50
Ψ(WetLN1700)	650.55	2.32	0.07	7	636.55
Ψ(WetLN1600)	650.95	2.73	0.05	7	636.95
Ψ(Wet1900)	651.09	2.86	0.05	7	637.09
Ψ(Wet1800)	651.50	3.28	0.04	7	637.50
Ψ(Wet1700)	651.57	3.35	0.04	7	637.57
Ψ(Wet1600)	651.76	3.53	0.04	7	637.76
Ψ(Wet1500)	652.05	3.82	0.03	7	638.05
Ψ(.)	652.05	3.83	0.03	6	640.05
Ψ(Wet1100)	652.10	3.87	0.03	7	638.10
Ψ(Wet1200)	652.28	4.05	0.03	7	638.28
Ψ(Wet1400)	652.38	4.15	0.03	7	638.38
Ψ(Wet1300)	652.52	4.29	0.03	7	638.52
Ψ(WetLN1500)	652.64	4.41	0.02	7	638.64

Appendix 5 continued.

Appendix 5.j Cope's Gray Treefrog Local Scale AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Area,SiteType)	646.01	0.00	0.29	8	630.01
Ψ(SiteType)	646.60	0.59	0.22	7	632.60
Ψ(PerCan,Area,SiteType)	647.99	1.99	0.11	9	629.99
Ψ(Area)	648.18	2.17	0.10	7	634.18
Ψ(Peri,SiteType)	648.31	2.30	0.09	8	632.31
Ψ(PerCan,SiteType)	648.41	2.40	0.09	8	632.41
Ψ(PerCan,Area)	650.13	4.13	0.04	8	634.13
Ψ(PerCan,Peri,SiteType)	650.24	4.23	0.04	9	632.24
Ψ(.)	652.05	6.05	0.01	6	640.05

Appendix 5.k Cope's Gray Treefrog Migration Scale AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ForLN1000)	620.26	0.00	0.47	7	606.26
Ψ(ForLN1000,ForClump1000)	621.74	1.48	0.22	8	605.74
Ψ(ForLN1000,StrDen1000)	621.93	1.67	0.20	8	605.93
Ψ(ForLN1000,ForClump1000,StrDen1000)	623.32	3.06	0.10	9	605.32
Ψ(.)	652.05	31.79	0.00	6	640.05

Appendix 5.l Cope's Gray Treefrog Dispersal Scale AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Impervious2000)	622.83	0.00	0.40	7	608.83
Ψ(Impervious2000,Hwy2000)	623.53	0.71	0.28	8	607.53
Ψ(Impervious2000,WetLN2000)	624.46	1.63	0.18	8	608.46
Ψ(Impervious2000,WetLN2000,Hwy2000)	624.93	2.10	0.14	9	606.93
Ψ(.)	652.05	29.23	0.00	6	640.05

Appendix 5.m Cope's Gray Treefrog Multi-scale Model AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(SiteType,ForLN1000)	614.21	0.00	0.05	8	598.21
Ψ(SiteType,ForClump1000,Impervious2000)	614.94	0.73	0.04	9	596.94
Ψ(SiteType,ForLN1000,WetLN2000)	614.98	0.77	0.04	9	596.98
Ψ(PerCan,SiteType,ForLN1000)	615.65	1.43	0.03	9	597.65

Appendix 5 continued.

Ψ(Peri,SiteType,ForLN1000)	615.67	1.46	0.03	9	597.67
Ψ(Area,SiteType,ForLN1000)	615.68	1.46	0.03	9	597.68
Ψ(SiteType,ForLN1000,ForClump1000)	616.05	1.84	0.02	9	598.05
Ψ(SiteType,ForLN1000,StrDen1000)	616.16	1.95	0.02	9	598.16
Ψ(SiteType,ForLN1000,Hwy2000)	616.19	1.98	0.02	9	598.19
Ψ(Peri,SiteType,ForLN1000,WetLN2000)	616.35	2.14	0.02	10	596.35
Ψ(Area,SiteType,ForLN1000,WetLN2000)	616.43	2.21	0.02	10	596.43
Ψ(PerCan,SiteType,ForLN1000,WetLN2000)	616.56	2.35	0.02	10	596.56
Ψ(PerCan,SiteType,ForClump1000,Impervious2000)	616.60	2.38	0.02	10	596.60
Ψ(Peri,SiteType,ForClump1000,Impervious2000)	616.63	2.41	0.02	10	596.63
Ψ(SiteType,ForClump1000,Impervious2000,WetLN2000)	616.66	2.45	0.02	10	596.66
Ψ(SiteType,ForClump1000,StrDen1000,Impervious2000)	616.72	2.51	0.02	10	596.72
Ψ(SiteType,ForLN1000,WetLN2000,Hwy2000)	616.73	2.52	0.02	10	596.73
Ψ(SiteType,ForLN1000,ForClump1000,WetLN2000)	616.75	2.53	0.02	10	596.75
Ψ(Area,SiteType,ForClump1000,Impervious2000)	616.80	2.58	0.01	10	596.80
Ψ(SiteType,ForClump1000,Impervious2000,Hwy2000)	616.89	2.68	0.01	10	596.89
Ψ(SiteType,ForLN1000,StrDen1000,WetLN2000)	616.97	2.76	0.01	10	596.97
Ψ(PerCan,Area,SiteType,ForLN1000)	617.21	2.99	0.01	10	597.21
Ψ(PerCan,Peri,SiteType,ForLN1000)	617.34	3.13	0.01	10	597.34
Ψ(Peri,SiteType,ForLN1000,StrDen1000)	617.45	3.24	0.01	10	597.45
Ψ(PerCan,SiteType,ForLN1000,StrDen1000)	617.51	3.30	0.01	10	597.51
Ψ(PerCan,SiteType,ForLN1000,ForClump1000)	617.52	3.31	0.01	10	597.52
Ψ(Area,SiteType,ForLN1000,StrDen1000)	617.54	3.33	0.01	10	597.54
Ψ(Area,SiteType,ForLN1000,ForClump1000)	617.57	3.36	0.01	10	597.57
Ψ(Peri,SiteType,ForLN1000,ForClump1000)	617.59	3.37	0.01	10	597.59
Ψ(PerCan,SiteType,ForLN1000,Hwy2000)	617.65	3.43	0.01	10	597.65
Ψ(Peri,SiteType,ForLN1000,Hwy2000)	617.67	3.46	0.01	10	597.67
Ψ(Area,SiteType,ForLN1000,Hwy2000)	617.68	3.46	0.01	10	597.68
Ψ(ForClump1000,Impervious2000)	617.90	3.68	0.01	8	601.90
Ψ(SiteType,ForLN1000,ForClump1000,StrDen1000)	617.97	3.76	0.01	10	597.97
Ψ(SiteType,ForLN1000,ForClump1000,Hwy2000)	618.05	3.84	0.01	10	598.05
Ψ(PerCan,Area,SiteType,ForLN1000,WetLN2000)	618.11	3.90	0.01	11	596.11
Ψ(SiteType,ForLN1000,StrDen1000,Hwy2000)	618.13	3.92	0.01	10	598.13
Ψ(PerCan,Peri,SiteType,ForLN1000,WetLN2000)	618.15	3.93	0.01	11	596.15
Ψ(Peri,SiteType,ForClump1000,StrDen1000,Impervious2000)	618.17	3.95	0.01	11	596.17
Ψ(Peri,SiteType,ForLN1000,ForClump1000,WetLN2000)	618.23	4.01	0.01	11	596.23
Ψ(Peri,SiteType,ForLN1000,StrDen1000,WetLN2000)	618.23	4.02	0.01	11	596.23
Ψ(PerCan,SiteType,ForClump1000,StrDen1000,Impervious2000)	618.23	4.02	0.01	11	596.23
Ψ(Peri,SiteType,ForLN1000,WetLN2000,Hwy2000)	618.26	4.04	0.01	11	596.26
Ψ(Area,SiteType,ForLN1000,ForClump1000,WetLN2000)	618.26	4.05	0.01	11	596.26

Appendix 5 continued.

Ψ(Area,SiteType,ForLN1000,WetLN2000,Hwy2000)	618.32	4.11	0.01	11	596.32
Ψ(Peri,SiteType,ForClump1000,Impervious2000,WetLN2000)	618.34	4.12	0.01	11	596.34
Ψ(PerCan,SiteType,ForClump1000,Impervious2000,WetLN2000)	618.36	4.15	0.01	11	596.36
Ψ(Area,SiteType,ForLN1000,StrDen1000,WetLN2000)	618.37	4.15	0.01	11	596.37
Ψ(PerCan,SiteType,ForLN1000,ForClump1000,WetLN2000)	618.38	4.17	0.01	11	596.38
Ψ(PerCan,SiteType,ForLN1000,WetLN2000,Hwy2000)	618.41	4.20	0.01	11	596.41
Ψ(PerCan,Peri,SiteType,ForClump1000,Impervious2000)	618.42	4.21	0.01	11	596.42
Ψ(PerCan,Area,SiteType,ForClump1000,Impervious2000)	618.46	4.25	0.01	11	596.46
Ψ(Area,SiteType,ForClump1000,Impervious2000,WetLN2000)	618.47	4.26	0.01	11	596.47
Ψ(Area,SiteType,ForClump1000,StrDen1000,Impervious2000)	618.49	4.28	0.01	11	596.49
Ψ(SiteType,ForClump1000,StrDen1000,Impervious2000,WetLN2000)	618.51	4.29	0.01	11	596.51
Ψ(PerCan,SiteType,ForLN1000,StrDen1000,WetLN2000)	618.51	4.30	0.01	11	596.51
Ψ(SiteType,ForClump1000,Impervious2000,WetLN2000,Hwy2000)	618.54	4.32	0.01	11	596.54
Ψ(PerCan,SiteType,ForClump1000,Impervious2000,Hwy2000)	618.57	4.35	0.01	11	596.57
Ψ(Area,ForClump1000,Impervious2000)	618.59	4.38	0.01	9	600.59
Ψ(Peri,SiteType,ForClump1000,Impervious2000,Hwy2000)	618.61	4.40	0.01	11	596.61
Ψ(SiteType,ForLN1000,ForClump1000,WetLN2000,Hwy2000)	618.63	4.41	0.01	11	596.63
Ψ(SiteType,ForClump1000,StrDen1000,Impervious2000,Hwy2000)	618.65	4.44	0.01	11	596.65
Ψ(SiteType,ForLN1000,StrDen1000,WetLN2000,Hwy2000)	618.72	4.51	0.01	11	596.72
Ψ(SiteType,ForLN1000,ForClump1000,StrDen1000,WetLN2000)	618.73	4.51	0.01	11	596.73
Ψ(Area,SiteType,ForClump1000,Impervious2000,Hwy2000)	618.78	4.56	0.01	11	596.78

Appendix 6 Fowler's toad AIC model selection results for the analysis of occupancy. All candidate models within confidence set, 10% of the highest Akaike weight, are displayed, as well as the "null" model without covariates. Ψ is the occupancy probability and p is the detection probability. Covariate names followed by a numerical value indicate the covariates extent, a LN indicates a pseudo-threshold relationship, and INT indicates an interaction term was included. Covariate names are: Background Noise Index = **Noise**, Beaufort Wind Score = **Beau**, Days Since Rain = **DaysRain**, Days Since Above Average Rain of Survey Period = **DaysAvgRain**, Sky and Weather Condition = **Sky**, Time of Day = **Time**, Time since Sunset = **Sunset**, Julian Date = **Jul**, Julian Date Quadratic Term = **JulSq**, Temperature = **Temp**, Wind Speed = **Wind**, Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

Appendix 6.a Fowler's Toad Survey-specific Covariates AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)p(Temp,Jul,DaysRain,Sunset)	533.15	0.00	0.33	6	521.15
Ψ(.)p(Temp,DaysRain,Jul,JulSq)	533.56	0.41	0.27	6	521.56
Ψ(.)p(Temp,Jul,DaysRain,Time)	534.36	1.21	0.18	6	522.36
Ψ(.)p(Temp,Jul,DaysRain,TimeLN)	535.25	2.10	0.12	6	523.25

Appendix 6.b Fowler's Toad Percent Forest Cover AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForLN400)	517.61	0.00	0.28	7	503.61
Ψ(ForLN300)	519.04	1.43	0.14	7	505.04
Ψ(ForLN500)	519.08	1.47	0.14	7	505.08
Ψ(ForLN600)	520.47	2.87	0.07	7	506.47
Ψ(For300)	520.48	2.88	0.07	7	506.48
Ψ(For400)	520.97	3.37	0.05	7	506.97
Ψ(ForLN700)	521.16	3.56	0.05	7	507.16
Ψ(ForLN800)	521.27	3.67	0.05	7	507.27
Ψ(For500)	522.01	4.40	0.03	7	508.01
Ψ(ForLN900)	522.10	4.49	0.03	7	508.10
Ψ(.)	533.15	15.54	0.00	6	521.15

Appendix 6.c Fowler's Toad Forest Clumpiness Index AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForClump500)	514.59	0.00	0.27	7	500.59
Ψ(ForClump800)	514.93	0.35	0.23	7	500.93
Ψ(ForClump600)	515.36	0.77	0.19	7	501.36
Ψ(ForClump700)	516.24	1.65	0.12	7	502.24

Appendix 6 continued.

Ψ(ForClump900)	517.13	2.54	0.08	7	503.13
Ψ(ForClump300)	517.33	2.74	0.07	7	503.33
Ψ(ForClump1000)	519.06	4.47	0.03	7	505.06
Ψ(.)	533.15	18.56	0.00	6	521.15

Appendix 6.d Fowler's Toad Percent Forest Cover/Clumpiness Interaction AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForClump500)	514.59	0.00	0.09	7	500.59
Ψ(ForLN500,ForClump500)	514.92	0.33	0.07	8	498.92
Ψ(ForClump800)	514.93	0.35	0.07	7	500.93
Ψ(For500,ForClump500)	515.22	0.64	0.06	8	499.22
Ψ(ForClump600)	515.36	0.77	0.06	7	501.36
Ψ(For300,ForClump300)	516.13	1.54	0.04	8	500.13
Ψ(ForClump700)	516.24	1.65	0.04	7	502.24
Ψ(ForLN400,ForClump400)	516.41	1.83	0.03	8	500.41
Ψ(ForLN800,ForClump800)	516.62	2.03	0.03	8	500.62
Ψ(ForLN600,ForClump600)	516.74	2.15	0.03	8	500.74
Ψ(ForLN300,ForClump300)	516.80	2.21	0.03	8	500.80
Ψ(ForLN500,ForClump500,ForClumpINTLN500)	516.86	2.27	0.03	9	498.86
Ψ(For800,ForClump800)	516.91	2.32	0.03	8	500.91
Ψ(For600,ForClump600)	516.94	2.35	0.03	8	500.94
Ψ(For500,ForClump500,ForClumpINT500)	516.96	2.37	0.03	9	498.96
Ψ(ForClump900)	517.13	2.54	0.02	7	503.13
Ψ(ForClump300)	517.33	2.74	0.02	7	503.33
Ψ(ForLN400,ForClump400,ForClumpINTLN400)	517.53	2.95	0.02	9	499.53
Ψ(ForLN700,ForClump700)	517.54	2.95	0.02	8	501.54
Ψ(ForLN400)	517.61	3.02	0.02	7	503.61
Ψ(For300,ForClump300,ForClumpINT300)	518.05	3.46	0.02	9	500.05
Ψ(For700,ForClump700)	518.05	3.47	0.02	8	502.05
Ψ(For600,ForClump600,ForClumpINT600)	518.34	3.76	0.01	9	500.34
Ψ(For400,ForClump400)	518.44	3.85	0.01	8	502.44
Ψ(For800,ForClump800,ForClumpINT800)	518.44	3.85	0.01	9	500.44
Ψ(ForLN800,ForClump800,ForClumpINTLN800)	518.61	4.02	0.01	9	500.61
Ψ(ForLN900,ForClump900)	518.70	4.11	0.01	8	502.70
Ψ(ForLN600,ForClump600,ForClumpINTLN600)	518.70	4.12	0.01	9	500.70
Ψ(ForLN300,ForClump300,ForClumpINTLN300)	518.79	4.20	0.01	9	500.79
Ψ(For400,ForClump400,ForClumpINT400)	518.99	4.40	0.01	9	500.99
Ψ(ForLN300)	519.04	4.45	0.01	7	505.04

Appendix 6 continued.

Ψ(ForClump1000)	519.06	4.47	0.01	7	505.06
Ψ(For900,ForClump900)	519.07	4.48	0.01	8	503.07
Ψ(ForLN500)	519.08	4.49	0.01	7	505.08
Ψ(.)	533.15	18.56	0.00	6	521.15

Appendix 6.e Fowler's Toad Stream Density AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)	533.15	0.00	0.21	6	521.15
Ψ(StrDen900)	534.92	1.77	0.09	7	520.92
Ψ(StrDen100)	534.97	1.82	0.08	7	520.97
Ψ(StrDen1000)	534.98	1.83	0.08	7	520.98
Ψ(StrDen800)	535.04	1.89	0.08	7	521.04
Ψ(StrDen700)	535.09	1.94	0.08	7	521.09
Ψ(StrDen300)	535.10	1.95	0.08	7	521.10
Ψ(StrDen200)	535.13	1.98	0.08	7	521.13
Ψ(StrDen500)	535.14	1.99	0.08	7	521.14
Ψ(StrDen400)	535.14	2.00	0.08	7	521.14
Ψ(StrDen600)	535.15	2.00	0.08	7	521.15

Appendix 6.f Fowler's Toad Percent Impervious Surface AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(Impervious2000)	524.64	0.00	0.15	7	510.64
Ψ(Impervious1900)	525.06	0.42	0.12	7	511.06
Ψ(Impervious1800)	525.40	0.76	0.10	7	511.40
Ψ(Impervious1700)	525.73	1.08	0.09	7	511.73
Ψ(Impervious1600)	526.09	1.45	0.07	7	512.09
Ψ(Impervious1500)	526.54	1.90	0.06	7	512.54
Ψ(Impervious1400)	526.99	2.35	0.05	7	512.99
Ψ(Impervious1300)	527.32	2.67	0.04	7	513.32
Ψ(ImperviousLN2000)	527.59	2.94	0.03	7	513.59
Ψ(Impervious1200)	527.59	2.95	0.03	7	513.59
Ψ(ImperviousLN1900)	527.71	3.07	0.03	7	513.71
Ψ(Impervious1100)	527.87	3.23	0.03	7	513.87
Ψ(ImperviousLN1800)	527.89	3.24	0.03	7	513.89
Ψ(ImperviousLN1700)	528.09	3.45	0.03	7	514.09
Ψ(ImperviousLN1600)	528.20	3.56	0.03	7	514.20
Ψ(ImperviousLN1500)	528.35	3.71	0.02	7	514.35

Appendix 6 continued.

Ψ(ImperviousLN1400)	528.43	3.78	0.02	7	514.43
Ψ(ImperviousLN1300)	528.58	3.94	0.02	7	514.58
Ψ(ImperviousLN1200)	529.07	4.43	0.02	7	515.07
Ψ(.)	533.15	8.51	0.00	6	521.15

Appendix 6.g Fowler's Toad Effective Mesh Size AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(MeshLN1100)	522.31	0.00	0.12	7	508.31
Ψ(MeshLN1200)	522.58	0.27	0.11	7	508.58
Ψ(MeshLN1300)	522.70	0.39	0.10	7	508.70
Ψ(MeshLN1500)	522.83	0.52	0.09	7	508.83
Ψ(MeshLN1400)	522.89	0.58	0.09	7	508.89
Ψ(MeshLN1600)	522.98	0.67	0.09	7	508.98
Ψ(MeshLN1700)	522.99	0.68	0.09	7	508.99
Ψ(MeshLN2000)	523.19	0.88	0.08	7	509.19
Ψ(MeshLN1800)	523.24	0.93	0.08	7	509.24
Ψ(MeshLN1900)	523.34	1.03	0.07	7	509.34
Ψ(Mesh1100)	526.67	4.37	0.01	7	512.67
Ψ(.)	533.15	10.84	0.00	6	521.15

Appendix 6.h Fowler's Toad Highway Density AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(Hwy2000)	526.44	0.00	0.27	7	512.44
Ψ(Hwy1900)	527.47	1.03	0.16	7	513.47
Ψ(Hwy1800)	527.81	1.37	0.14	7	513.81
Ψ(Hwy1700)	527.87	1.43	0.13	7	513.87
Ψ(Hwy1600)	528.34	1.90	0.11	7	514.34
Ψ(Hwy1500)	529.23	2.79	0.07	7	515.23
Ψ(Hwy1400)	530.03	3.59	0.05	7	516.03
Ψ(.)	533.15	6.71	0.01	6	521.15

Appendix 6.i Fowler's Toad Percent Wetland Cover AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)	533.15	0.00	0.09	6	521.15
Ψ(WetLN1600)	534.02	0.87	0.06	7	520.02
Ψ(WetLN1700)	534.03	0.88	0.06	7	520.03

Appendix 6 continued.

Ψ(WetLN1500)	534.32	1.18	0.05	7	520.32
Ψ(WetLN2000)	534.36	1.21	0.05	7	520.36
Ψ(WetLN1200)	534.42	1.27	0.05	7	520.42
Ψ(Wet1700)	534.48	1.33	0.05	7	520.48
Ψ(Wet1600)	534.54	1.39	0.05	7	520.54
Ψ(WetLN1900)	534.55	1.40	0.05	7	520.55
Ψ(Wet1900)	534.58	1.43	0.05	7	520.58
Ψ(WetLN1800)	534.58	1.43	0.05	7	520.58
Ψ(WetLN1100)	534.60	1.45	0.04	7	520.60
Ψ(Wet1800)	534.60	1.45	0.04	7	520.60
Ψ(Wet1500)	534.60	1.45	0.04	7	520.60
Ψ(WetLN1300)	534.63	1.49	0.04	7	520.63
Ψ(Wet2000)	534.64	1.49	0.04	7	520.64
Ψ(WetLN1400)	534.79	1.64	0.04	7	520.79
Ψ(Wet1400)	534.83	1.68	0.04	7	520.83
Ψ(Wet1300)	534.99	1.84	0.04	7	520.99
Ψ(Wet1200)	535.06	1.92	0.04	7	521.06
Ψ(Wet1100)	535.15	2.00	0.03	7	521.15

Appendix 6.j Fowler's Toad Local Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(Peri)	531.80	0.00	0.28	7	517.80
Ψ(.)	533.15	1.34	0.15	6	521.15
Ψ(PerCan,Peri)	533.53	1.72	0.12	8	517.53
Ψ(Peri,SiteType)	533.80	1.99	0.11	8	517.80
Ψ(Area)	534.12	2.31	0.09	7	520.12
Ψ(SiteType)	535.01	3.20	0.06	7	521.01
Ψ(PerCan)	535.11	3.30	0.05	7	521.11
Ψ(PerCan,Peri,SiteType)	535.50	3.69	0.04	9	517.50
Ψ(PerCan,Area)	535.94	4.13	0.04	8	519.94
Ψ(Area,SiteType)	536.32	4.52	0.03	8	520.32

Appendix 6.k Fowler's Toad Migration Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForLN400,ForClump500)	514.05	0.00	0.35	8	498.05
Ψ(ForClump500)	514.59	0.54	0.26	7	500.59
Ψ(ForLN400,ForClump500,StrDen900)	515.46	1.41	0.17	9	497.46

Appendix 6 continued.

Ψ(ForClump500,StrDen900)	515.99	1.94	0.13	8	499.99
Ψ(ForLN400)	517.61	3.56	0.06	7	503.61
Ψ(.)	533.15	19.10	0.00	6	521.15

Appendix 6.l Fowler's Toad Dispersal Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(MeshLN1100)	522.31	0.00	0.29	7	508.31
Ψ(MeshLN1100,Hwy2000)	523.19	0.88	0.19	8	507.19
Ψ(WetLN1600,MeshLN1100)	524.19	1.88	0.12	8	508.19
Ψ(Impervious2000,Hwy2000)	524.34	2.03	0.11	8	508.34
Ψ(Impervious2000)	524.64	2.33	0.09	7	510.64
Ψ(WetLN1600,MeshLN1100,Hwy2000)	525.02	2.72	0.08	9	507.02
Ψ(Impervious2000,WetLN1600,Hwy2000)	526.33	4.02	0.04	9	508.33
Ψ(Hwy2000)	526.44	4.13	0.04	7	512.44
Ψ(Impervious2000,WetLN1600)	526.63	4.32	0.03	8	510.63
Ψ(.)	533.15	10.84	0.00	6	521.15

Appendix 6.m Fowler's Toad Multi-scale Model AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForClump500,Hwy2000)	510.33	0.00	0.04	8	494.33
Ψ(ForClump500,MeshLN1100,Hwy2000)	511.72	1.39	0.02	9	493.72
Ψ(Peri,ForClump500,Hwy2000)	511.81	1.48	0.02	9	493.81
Ψ(ForClump500,StrDen900,Hwy2000)	511.94	1.61	0.02	9	493.94
Ψ(ForLN400,ForClump500,Hwy2000)	512.11	1.78	0.02	9	494.11
Ψ(PerCan,ForClump500,Hwy2000)	512.11	1.78	0.02	9	494.11
Ψ(Area,ForClump500,Hwy2000)	512.19	1.86	0.02	9	494.19
Ψ(ForClump500,Impervious2000,Hwy2000)	512.27	1.94	0.02	9	494.27
Ψ(ForClump500,WetLN1600,Hwy2000)	512.31	1.98	0.02	9	494.31
Ψ(SiteType,ForClump500,Hwy2000)	512.32	1.99	0.02	9	494.32
Ψ(ForClump500,MeshLN1100)	512.35	2.02	0.02	8	496.35
Ψ(PerCan,ForClump500,MeshLN1100,Hwy2000)	513.27	2.94	0.01	10	493.27
Ψ(PerCan,Peri,ForClump500,Hwy2000)	513.30	2.98	0.01	10	493.30
Ψ(Peri,ForClump500,MeshLN1100,Hwy2000)	513.33	3.00	0.01	10	493.33
Ψ(Area,ForClump500,MeshLN1100,Hwy2000)	513.47	3.14	0.01	10	493.47
Ψ(ForClump500,StrDen900,MeshLN1100,Hwy2000)	513.52	3.19	0.01	10	493.52
Ψ(PerCan,ForClump500,StrDen900,Hwy2000)	513.58	3.25	0.01	10	493.58
Ψ(Peri,ForClump500,StrDen900,Hwy2000)	513.59	3.26	0.01	10	493.59

Appendix 6 continued.

Ψ(Peri,ForClump500,MeshLN1100)	513.65	3.32	0.01	9	495.65
Ψ(Peri,ForLN400,ForClump500,Hwy2000)	513.65	3.32	0.01	10	493.65
Ψ(Area,ForClump500,StrDen900,Hwy2000)	513.69	3.36	0.01	10	493.69
Ψ(ForLN400,ForClump500,MeshLN1100,Hwy2000)	513.69	3.36	0.01	10	493.69
Ψ(SiteType,ForClump500,MeshLN1100,Hwy2000)	513.70	3.37	0.01	10	493.70
Ψ(ForLN400,ForClump500,StrDen900,Hwy2000)	513.71	3.38	0.01	10	493.71
Ψ(ForClump500,WetLN1600,MeshLN1100,Hwy2000)	513.71	3.38	0.01	10	493.71
Ψ(Peri,ForClump500,Impervious2000,Hwy2000)	513.77	3.44	0.01	10	493.77
Ψ(Peri,SiteType,ForClump500,Hwy2000)	513.78	3.45	0.01	10	493.78
Ψ(PerCan,ForLN400,ForClump500,Hwy2000)	513.79	3.46	0.01	10	493.79
Ψ(Peri,ForClump500,WetLN1600,Hwy2000)	513.79	3.46	0.01	10	493.79
Ψ(ForClump500,StrDen900,Impervious2000,Hwy2000)	513.88	3.55	0.01	10	493.88
Ψ(SiteType,ForClump500,StrDen900,Hwy2000)	513.91	3.58	0.01	10	493.91
Ψ(PerCan,ForClump500,MeshLN1100)	513.91	3.58	0.01	9	495.91
Ψ(ForClump500,StrDen900,WetLN1600,Hwy2000)	513.94	3.61	0.01	10	493.94
Ψ(Area,ForLN400,ForClump500,Hwy2000)	513.95	3.62	0.01	10	493.95
Ψ(PerCan,ForClump500,Impervious2000,Hwy2000)	514.00	3.67	0.01	10	494.00
Ψ(PerCan,Area,ForClump500,Hwy2000)	514.02	3.69	0.01	10	494.02
Ψ(ForLN400,ForClump500,MeshLN1100)	514.04	3.71	0.01	9	496.04
Ψ(ForLN400,ForClump500)	514.05	3.72	0.01	8	498.05
Ψ(PerCan,ForClump500,WetLN1600,Hwy2000)	514.08	3.75	0.01	10	494.08
Ψ(ForLN400,ForClump500,WetLN1600,Hwy2000)	514.09	3.76	0.01	10	494.09
Ψ(SiteType,ForLN400,ForClump500,Hwy2000)	514.10	3.77	0.01	10	494.10
Ψ(PerCan,SiteType,ForClump500,Hwy2000)	514.11	3.78	0.01	10	494.11
Ψ(Area,ForClump500,Impervious2000,Hwy2000)	514.12	3.79	0.01	10	494.12
Ψ(Area,ForClump500,WetLN1600,Hwy2000)	514.15	3.82	0.01	10	494.15
Ψ(Area,SiteType,ForClump500,Hwy2000)	514.18	3.85	0.01	10	494.18
Ψ(Area,ForClump500,MeshLN1100)	514.26	3.93	0.01	9	496.26
Ψ(SiteType,ForClump500,Impervious2000,Hwy2000)	514.26	3.93	0.01	10	494.26
Ψ(ForClump500,Impervious2000,WetLN1600,Hwy2000)	514.26	3.93	0.01	10	494.26
Ψ(ForClump500,StrDen900,MeshLN1100)	514.26	3.93	0.01	9	496.26
Ψ(SiteType,ForClump500,WetLN1600,Hwy2000)	514.29	3.96	0.01	10	494.29
Ψ(SiteType,ForClump500,MeshLN1100)	514.32	3.99	0.01	9	496.32
Ψ(ForClump500,WetLN1600,MeshLN1100)	514.35	4.02	0.01	9	496.35
Ψ(ForClump500,Impervious2000)	514.47	4.14	0.01	8	498.47
Ψ(PerCan,Peri,ForClump500,MeshLN1100,Hwy2000)	514.55	4.22	0.01	11	492.55
Ψ(ForClump500)	514.59	4.26	0.01	7	500.59
Ψ(Peri,ForClump500)	514.77	4.44	0.00	8	498.77
Ψ(PerCan,Peri,ForClump500,MeshLN1100)	514.84	4.51	0.00	10	494.84

Appendix 6 continued.

Ψ(.)	533.15	22.82	0.00	6	521.15

Appendix 7 Green Treefrog AIC model selection results for the analysis of occupancy. All candidate models within confidence set, 10% of the highest Akaike weight, are displayed, as well as the "null" model without covariates. Ψ is the occupancy probability and p is the detection probability. Covariate names followed by a numerical value indicate the covariates extent, a LN indicates a pseudo-threshold relationship, and INT indicates an interaction term was included. Covariate names are: Background Noise Index = **Noise**, Beaufort Wind Score = **Beau**, Days Since Rain = **DaysRain**, Days Since Above Average Rain of Survey Period = **DaysAvgRain**, Sky and Weather Condition = **Sky**, Time of Day = **Time**, Time since Sunset = **Sunset**, Julian Date = **Jul**, Julian Date Quadratic Term = **JulSq**, Temperature = **Temp**, Wind Speed = **Wind**, Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

Appendix 7.a Green Treefrog Survey-specific Covariates AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)p(Temp,Jul,JulSq)	614.80	0.00	0.19	5	604.80
Ψ(.)p(Temp,DaysAvgRain,Jul,JulSq)	615.34	0.54	0.15	6	603.34
Ψ(.)p(Temp,Wind,Jul,JulSq)	615.67	0.88	0.12	6	603.67
Ψ(.)p(Temp,Sunset,Jul,JulSq)	616.61	1.81	0.08	6	604.61
Ψ(.)p(Temp,Time,Jul,JulSq)	616.63	1.83	0.08	6	604.63
Ψ(.)p(Temp,Jul,JulSq,TimeLN)	616.68	1.88	0.08	6	604.68
Ψ(.)p(Temp,Jul,JulSq,SunsetLN)	616.69	1.89	0.08	6	604.69
Ψ(.)p(Temp,Jul,JulSq,DaysRainLN)	616.71	1.91	0.07	6	604.71
Ψ(.)p(Temp,DaysRain,Jul,JulSq)	616.78	1.99	0.07	6	604.78
Ψ(.)p(Temp,Jul,JulSq,DaysAvgRainLN)	616.79	1.99	0.07	6	604.79

Appendix 7.b Green Treefrog Percent Forest Cover AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForLN1000)	612.64	0.00	0.12	6	600.64
Ψ(For1000)	613.09	0.44	0.10	6	601.09
Ψ(ForLN900)	613.12	0.48	0.10	6	601.12
Ψ(ForLN800)	613.36	0.72	0.08	6	601.36
Ψ(For900)	613.58	0.94	0.08	6	601.58
Ψ(For800)	614.06	1.42	0.06	6	602.06
Ψ(ForLN700)	614.09	1.45	0.06	6	602.09
Ψ(For700)	614.73	2.09	0.04	6	602.73
Ψ(ForLN600)	614.77	2.13	0.04	6	602.77

Appendix 7 continued.

Ψ(.)	614.80	2.15	0.04	5	604.80
Ψ(For600)	615.01	2.37	0.04	6	603.01
Ψ(ForLN400)	615.25	2.60	0.03	6	603.25
Ψ(ForLN500)	615.35	2.71	0.03	6	603.35
Ψ(For500)	615.49	2.85	0.03	6	603.49
Ψ(ForLN300)	615.68	3.04	0.03	6	603.68
Ψ(ForLN100)	615.79	3.14	0.03	6	603.79
Ψ(ForLN200)	615.91	3.27	0.02	6	603.91
Ψ(For400)	615.95	3.31	0.02	6	603.95
Ψ(For300)	616.16	3.51	0.02	6	604.16
Ψ(For200)	616.44	3.79	0.02	6	604.44
Ψ(For100)	616.62	3.97	0.02	6	604.62

Appendix 7.c Green Treefrog Forest Clumpiness Index AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForClump1000)	611.46	0.00	0.32	6	599.46
Ψ(ForClump900)	612.35	0.89	0.21	6	600.35
Ψ(ForClump800)	613.16	1.70	0.14	6	601.16
Ψ(ForClump200)	614.33	2.87	0.08	6	602.33
Ψ(.)	614.80	3.34	0.06	5	604.80
Ψ(ForClump700)	614.86	3.40	0.06	6	602.86
Ψ(ForClump400)	615.91	4.45	0.03	6	603.91

Appendix 7.d Green Treefrog Percent Forest Cover/Clumpiness Interaction AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForLN200,ForClump200)	611.00	0.00	0.08	7	597.00
Ψ(ForClump1000)	611.46	0.46	0.07	6	599.46
Ψ(ForLN400,ForClump400)	611.97	0.97	0.05	7	597.97
Ψ(ForLN200,ForClump200,ForClumpINTLN200)	612.05	1.05	0.05	8	596.05
Ψ(ForClump900)	612.35	1.35	0.04	6	600.35
Ψ(ForLN1000)	612.64	1.65	0.04	6	600.64
Ψ(For1000)	613.09	2.09	0.03	6	601.09
Ψ(ForLN900)	613.12	2.12	0.03	6	601.12
Ψ(ForClump800)	613.16	2.16	0.03	6	601.16
Ψ(For1000,ForClump1000)	613.27	2.27	0.03	7	599.27
Ψ(ForLN1000,ForClump1000)	613.32	2.33	0.03	7	599.32

Appendix 7 continued.

Ψ(ForLN800)	613.36	2.36	0.03	6	601.36
Ψ(For900)	613.58	2.59	0.02	6	601.58
Ψ(ForLN400,ForClump400,ForClumpINTLN400)	613.83	2.83	0.02	8	597.83
Ψ(For800)	614.06	3.06	0.02	6	602.06
Ψ(ForLN900,ForClump900)	614.09	3.09	0.02	7	600.09
Ψ(ForLN700)	614.09	3.10	0.02	6	602.09
Ψ(For900,ForClump900)	614.10	3.10	0.02	7	600.10
Ψ(ForLN500,ForClump500)	614.12	3.12	0.02	7	600.12
Ψ(For1000,ForClump1000,ForClumpINT1000)	614.30	3.31	0.02	8	598.30
Ψ(ForClump200)	614.33	3.33	0.02	6	602.33
Ψ(For200,ForClump200)	614.54	3.54	0.01	7	600.54
Ψ(For700)	614.73	3.73	0.01	6	602.73
Ψ(ForLN800,ForClump800)	614.76	3.76	0.01	7	600.76
Ψ(ForLN600)	614.77	3.78	0.01	6	602.77
Ψ(.)	614.80	3.80	0.01	5	604.80
Ψ(ForClump700)	614.86	3.86	0.01	6	602.86
Ψ(For800,ForClump800)	614.90	3.90	0.01	7	600.90
Ψ(For600)	615.01	4.02	0.01	6	603.01
Ψ(ForLN1000,ForClump1000,ForClumpINTLN1000)	615.06	4.06	0.01	8	599.06
Ψ(ForLN400)	615.25	4.25	0.01	6	603.25
Ψ(ForLN500)	615.35	4.36	0.01	6	603.35
Ψ(For500)	615.49	4.49	0.01	6	603.49
Ψ(For400,ForClump400)	615.58	4.58	0.01	7	601.58

Appendix 7.e Green Treefrog Stream Density AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(StrDen400)	612.29	0.00	0.23	6	600.29
Ψ(StrDen300)	612.82	0.53	0.18	6	600.82
Ψ(StrDen500)	613.15	0.86	0.15	6	601.15
Ψ(StrDen200)	613.98	1.69	0.10	6	601.98
Ψ(StrDen600)	614.34	2.05	0.08	6	602.34
Ψ(StrDen100)	614.70	2.41	0.07	6	602.70
Ψ(.)	614.80	2.51	0.07	5	604.80
Ψ(StrDen700)	615.64	3.35	0.04	6	603.64
Ψ(StrDen800)	616.57	4.28	0.03	6	604.57
Ψ(StrDen900)	616.68	4.39	0.03	6	604.68
Ψ(StrDen1000)	616.79	4.50	0.02	6	604.79

Appendix 7 continued.

Appendix 7.f Green Treefrog Percent Impervious Impervious Surface AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ImperviousLN1600)	604.08	0.00	0.11	6	592.08
Ψ(ImperviousLN1500)	604.09	0.00	0.11	6	592.09
Ψ(ImperviousLN1700)	604.15	0.06	0.10	6	592.15
Ψ(ImperviousLN1400)	604.20	0.12	0.10	6	592.20
Ψ(ImperviousLN1800)	604.35	0.27	0.09	6	592.35

Appendix 7 continued.

Ψ(ImperviousLN1900)	604.56	0.47	0.08	6	592.56
Ψ(ImperviousLN1300)	604.56	0.48	0.08	6	592.56
Ψ(ImperviousLN2000)	604.75	0.66	0.08	6	592.75
Ψ(ImperviousLN1200)	604.89	0.80	0.07	6	592.89
Ψ(ImperviousLN1100)	605.21	1.12	0.06	6	593.21
Ψ(Impervious2000)	607.81	3.72	0.02	6	595.81
Ψ(Impervious1900)	607.88	3.79	0.02	6	595.88
Ψ(Impervious1800)	607.92	3.83	0.02	6	595.92
Ψ(Impervious1700)	608.05	3.96	0.01	6	596.05
Ψ(Impervious1600)	608.34	4.25	0.01	6	596.34
Ψ(Impervious1500)	608.66	4.57	0.01	6	596.66
Ψ(.)	614.80	10.71	0.00	5	604.80

Appendix 7.g Green Treefrog Effective Mesh Size AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Mesh1200)	609.05	0.00	0.07	6	597.05
Ψ(Mesh1300)	609.12	0.06	0.07	6	597.12
Ψ(Mesh1100)	609.12	0.07	0.07	6	597.12
Ψ(Mesh1400)	609.15	0.10	0.07	6	597.15
Ψ(Mesh1500)	609.20	0.15	0.07	6	597.20
Ψ(MeshLN1100)	609.37	0.32	0.06	6	597.37
Ψ(Mesh1600)	609.39	0.34	0.06	6	597.39
Ψ(Mesh1700)	609.58	0.53	0.06	6	597.58
Ψ(MeshLN1200)	609.61	0.56	0.05	6	597.61
Ψ(MeshLN1300)	609.75	0.70	0.05	6	597.75
Ψ(Mesh2000)	609.76	0.71	0.05	6	597.76
Ψ(Mesh1900)	609.88	0.82	0.05	6	597.88
Ψ(Mesh1800)	609.90	0.85	0.05	6	597.90

Appendix 7 continued.

Appendix 7 continued.

Ψ(MeshLN1400)	610.15	1.10	0.04	6	598.15
Ψ(MeshLN1500)	610.40	1.34	0.04	6	598.40
Ψ(MeshLN1600)	610.69	1.64	0.03	6	598.69
Ψ(MeshLN2000)	610.82	1.77	0.03	6	598.82
Ψ(MeshLN1700)	610.85	1.80	0.03	6	598.85
Ψ(MeshLN1900)	610.99	1.93	0.03	6	598.99
Ψ(MeshLN1800)	611.01	1.95	0.03	6	599.01
Ψ(.)	614.80	5.74	0.00	5	604.80

Appendix 7.h Green Treefrog Highway Density AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(.)	614.80	0.00	0.18	5	604.80
Ψ(Hwy2000)	615.80	1.00	0.11	6	603.80
Ψ(Hwy1900)	615.99	1.19	0.10	6	603.99
Ψ(Hwy1800)	616.06	1.27	0.09	6	604.06
Ψ(Hwy1700)	616.09	1.30	0.09	6	604.09
Ψ(Hwy1600)	616.39	1.60	0.08	6	604.39
Ψ(Hwy1100)	616.62	1.83	0.07	6	604.62
Ψ(Hwy1200)	616.63	1.84	0.07	6	604.63
Ψ(Hwy1500)	616.67	1.88	0.07	6	604.67
Ψ(Hwy1400)	616.68	1.89	0.07	6	604.68
Ψ(Hwy1300)	616.69	1.89	0.07	6	604.69

Appendix 7.i Green Treefrog Percent Wetland Cover AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Wet1200)	613.55	0.00	0.10	6	601.55
Ψ(Wet1100)	613.68	0.13	0.10	6	601.68
Ψ(Wet1300)	613.89	0.34	0.09	6	601.89
Ψ(Wet1400)	614.25	0.70	0.07	6	602.25
Ψ(Wet1500)	614.57	1.02	0.06	6	602.57
Ψ(Wet1600)	614.62	1.06	0.06	6	602.62
Ψ(Wet1700)	614.64	1.09	0.06	6	602.64
Ψ(.)	614.80	1.25	0.05	5	604.80
Ψ(Wet1800)	614.93	1.38	0.05	6	602.93
Ψ(Wet1900)	615.15	1.60	0.05	6	603.15
Ψ(Wet2000)	615.27	1.72	0.04	6	603.27

Appendix 7 continued.

Ψ(WetLN1600)	615.47	1.92	0.04	6	603.47
Ψ(WetLN1700)	615.59	2.04	0.04	6	603.59
Ψ(WetLN1800)	616.04	2.49	0.03	6	604.04
Ψ(WetLN2000)	616.12	2.57	0.03	6	604.12
Ψ(WetLN1500)	616.15	2.60	0.03	6	604.15
Ψ(WetLN1900)	616.23	2.68	0.03	6	604.23
Ψ(WetLN1400)	616.60	3.05	0.02	6	604.60
Ψ(WetLN1100)	616.68	3.13	0.02	6	604.68
Ψ(WetLN1200)	616.75	3.20	0.02	6	604.75
Ψ(WetLN1300)	616.76	3.20	0.02	6	604.76

Appendix 7.j Green Treefrog Local Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(Area)	599.10	0.00	0.47	6	587.10
Ψ(PerCan,Area)	600.33	1.22	0.25	7	586.33
Ψ(Area,SiteType)	601.09	1.99	0.17	7	587.09
Ψ(PerCan,Area,SiteType)	602.25	3.15	0.10	8	586.25
Ψ(.)	614.80	15.69	0.00	5	604.80

Appendix 7.k Green Treefrog Migration Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForClump1000,StrDen400)	608.15	0.00	0.36	7	594.15
Ψ(ForLN1000,ForClump1000,StrDen400)	610.14	1.99	0.13	8	594.14
Ψ(ForLN1000,StrDen400)	610.14	1.99	0.13	7	596.14
Ψ(ForLN200,ForClump200,StrDen400)	610.70	2.55	0.10	8	594.70
Ψ(ForLN200,ForClump200)	611.00	2.85	0.09	7	597.00
Ψ(ForClump1000)	611.46	3.31	0.07	6	599.46
Ψ(StrDen400)	612.29	4.13	0.05	6	600.29
Ψ(ForLN1000)	612.64	4.49	0.04	6	600.64
Ψ(.)	614.80	6.64	0.01	5	604.80

Appendix 7.l Green Treefrog Dispersal Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ImperviousLN1600)	604.08	0.00	0.36	6	592.08
Ψ(ImperviousLN1600,Hwy2000)	605.00	0.91	0.22	7	591.00

Appendix 7 continued.

Ψ(ImperviousLN1600,Wet1200)	605.14	1.05	0.21	7	591.14
Ψ(ImperviousLN1600,Wet1200,Hwy2000)	606.08	2.00	0.13	8	590.08
Ψ(.)	614.80	10.71	0.00	5	604.80

Appendix 7.m Green Treefrog Multi-scale Model AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(PerCan,Area,ForLN200,ForClump200,ImperviousLN1600)	592.75	0.00	0.10	10	572.75
Ψ(Area,ForLN200,ForClump200,ImperviousLN1600,Hwy2000)	593.37	0.62	0.07	10	573.37
Ψ(Area,ForLN200,ForClump200,ImperviousLN1600)	593.45	0.70	0.07	9	575.45
Ψ(Area,ForLN200,ForClump200)	595.10	2.35	0.03	8	579.10
Ψ(PerCan,Area,ForLN200,ForClump200)	595.25	2.50	0.03	9	577.25
Ψ(Area,ForLN200,ForClump200,ImperviousLN1600,Wet1200)	595.27	2.52	0.03	10	575.27
Ψ(Area,SiteType,ForLN200,ForClump200,ImperviousLN1600)	595.43	2.68	0.03	10	575.43
Ψ(Area,ForLN200,ForClump200,StrDen400,ImperviousLN1600)	595.45	2.70	0.03	10	575.45
Ψ(PerCan,Area,ForLN200,ForClump200,Mesh1200)	595.81	3.06	0.02	10	575.81
Ψ(Area,ForLN200,ForClump200,Mesh1200)	596.11	3.36	0.02	9	578.11
Ψ(Area,ForLN200,ForClump200,Wet1200)	596.20	3.45	0.02	9	578.20
Ψ(Area,ForLN200,ForClump200,Mesh1200,Hwy2000)	596.34	3.59	0.02	10	576.34
Ψ(Area,ForLN200,ForClump200,Hwy2000)	596.41	3.66	0.02	9	578.41
Ψ(PerCan,Area,ForLN200,ForClump200,Wet1200)	596.44	3.69	0.02	10	576.44
Ψ(PerCan,Area,ForLN200,ForClump200,Hwy2000)	596.71	3.96	0.01	10	576.71
Ψ(PerCan,Area,SiteType,ForLN200,ForClump200)	597.00	4.25	0.01	10	577.00
Ψ(Area,SiteType,ForLN200,ForClump200)	597.06	4.31	0.01	9	579.06
Ψ(Area,ForLN200,ForClump200,StrDen400)	597.10	4.35	0.01	9	579.10
Ψ(PerCan,Area,ForLN200,ForClump200,StrDen400)	597.17	4.42	0.01	10	577.17
Ψ(Area,ImperviousLN1600,Hwy2000)	597.31	4.56	0.01	8	581.31
Ψ(Area,ForLN200,ForClump200,Wet1200,Hwy2000)	597.33	4.58	0.01	10	577.33
Ψ(.)	614.80	22.05	0.00	5	604.80

Appendix 8 Green frog AIC model selection results for the analysis of occupancy. All candidate models within confidence set, 10% of the highest Akaike weight, are displayed, as well as the "null" model without covariates. Ψ is the occupancy probability and p is the detection probability. Covariate names followed by a numerical value indicate the covariates extent, a LN indicates a pseudo-threshold relationship, and INT indicates an interaction term was included. Covariate names are: Background Noise Index = **Noise**, Beaufort Wind Score = **Beau**, Days Since Rain = **DaysRain**, Days Since Above Average Rain of Survey Period = **DaysAvgRain**, Sky and Weather Condition = **Sky**, Time of Day = **Time**, Time since Sunset = **Sunset**, Julian Date = **Jul**, Julian Date Quadratic Term = **JulSq**, Temperature = **Temp**, Wind Speed = **Wind**, Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

Appendix 8.a Green Frog Survey-specific Covariates AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(.)p(DaysAvgRain,Noise1,Noise2,Noise3and4Com)	667.15	0.00	0.15	6	655.15
Ψ(.)p(Time,Noise1,Noise2,Noise3and4Com)	667.73	0.58	0.11	6	655.73
Ψ(.)p(Noise1,Noise2,Noise3and4Com,TimeLN)	667.82	0.67	0.11	6	655.82
Ψ(.)p(Noise1,Noise2,Noise3and4Com)	667.96	0.81	0.10	5	657.96
Ψ(.)p(Sunset,Noise1,Noise2,Noise3and4Com)	668.06	0.91	0.10	6	656.06
Ψ(.)p(Wind,Noise1,Noise2,Noise3and4Com)	668.26	1.11	0.09	6	656.26
Ψ(.)p(Noise1,Noise2,Noise3and4Com,SunsetLN)	668.58	1.43	0.07	6	656.58
Ψ(.)p(Noise1,Noise2,Noise3and4Com,DaysAvgRainLN)	668.77	1.62	0.07	6	656.77
Ψ(.)p(Noise1,Noise2,Noise3and4Com,DaysRainLN)	669.03	1.88	0.06	6	657.03
Ψ(.)p(Temp,Noise1,Noise2,Noise3and4Com)	669.23	2.09	0.05	6	657.23
Ψ(.)p(DaysRain,Noise1,Noise2,Noise3and4Com)	669.51	2.36	0.05	6	657.51
Ψ(.)p(Jul,Noise1,Noise2,Noise3and4Com)	669.93	2.78	0.04	6	657.93

Appendix 8.b Green Frog Percent Forest Cover AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(For1000)	640.19	0.00	0.32	7	626.19
Ψ(For900)	640.92	0.73	0.22	7	626.92
Ψ(ForLN1000)	642.38	2.19	0.11	7	628.38
Ψ(For800)	642.56	2.36	0.10	7	628.56
Ψ(ForLN900)	643.48	3.28	0.06	7	629.48
Ψ(For700)	643.58	3.39	0.06	7	629.58
Ψ(For600)	644.33	4.14	0.04	7	630.33
Ψ(.)	667.15	26.96	0.00	6	655.15

Appendix 8 continued.

Appendix 8.c Green Frog Forest Clumpiness Index AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ForClump1000)	642.16	0.00	0.70	7	628.16
Ψ(ForClump900)	644.42	2.26	0.23	7	630.42
Ψ(.)	667.15	24.98	0.00	6	655.15

Appendix 8.d Green Frog Percent Forest Cover/Clumpiness Interaction AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(For1000,ForClump1000)	638.87	0.00	0.19	8	622.87
Ψ(For900,ForClump900)	640.06	1.19	0.10	8	624.06
Ψ(For1000)	640.19	1.32	0.10	7	626.19
Ψ(For1000,ForClump1000,ForClumpINT1000)	640.87	2.00	0.07	9	622.87
Ψ(For900)	640.92	2.05	0.07	7	626.92
Ψ(ForLN1000,ForClump1000)	641.25	2.38	0.06	8	625.25
Ψ(For900,ForClump900,ForClumpINT900)	641.85	2.98	0.04	9	623.85
Ψ(ForClump1000)	642.16	3.30	0.04	7	628.16
Ψ(ForLN1000,ForClump1000,ForClumpINTLN1000)	642.34	3.47	0.03	9	624.34
Ψ(ForLN1000)	642.38	3.52	0.03	7	628.38
Ψ(For800,ForClump800)	642.40	3.53	0.03	8	626.40
Ψ(For800)	642.56	3.69	0.03	7	628.56
Ψ(ForLN900,ForClump900)	642.57	3.70	0.03	8	626.57
Ψ(.)	667.15	28.28	0.00	6	655.15

Appendix 8.e Green Frog Stream Density AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(StrDen500)	666.42	0.00	0.14	7	652.42
Ψ(StrDen300)	666.57	0.15	0.13	7	652.57
Ψ(StrDen400)	666.79	0.37	0.12	7	652.79
Ψ(StrDen600)	666.85	0.44	0.12	7	652.85
Ψ(.)	667.15	0.73	0.10	6	655.15
Ψ(StrDen200)	667.47	1.05	0.08	7	653.47
Ψ(StrDen100)	667.56	1.14	0.08	7	653.56
Ψ(StrDen700)	667.68	1.26	0.08	7	653.68
Ψ(StrDen800)	668.43	2.02	0.05	7	654.43
Ψ(StrDen900)	668.53	2.11	0.05	7	654.53
Ψ(StrDen1000)	668.76	2.34	0.04	7	654.76

Appendix 8 continued.

Appendix 8.f Green Frog Percent Impervious Impervious Surface AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ImperviousLN1400)	640.64	0.00	0.11	7	626.64
Ψ(ImperviousLN1500)	640.70	0.05	0.11	7	626.70
Ψ(ImperviousLN1600)	640.72	0.08	0.11	7	626.72
Ψ(ImperviousLN1300)	640.73	0.09	0.11	7	626.73
Ψ(ImperviousLN1200)	641.06	0.41	0.09	7	627.06
Ψ(ImperviousLN1700)	641.09	0.45	0.09	7	627.09
Ψ(ImperviousLN1800)	641.36	0.72	0.08	7	627.36
Ψ(ImperviousLN1100)	641.51	0.87	0.07	7	627.51
Ψ(ImperviousLN1900)	641.54	0.90	0.07	7	627.54
Ψ(ImperviousLN2000)	641.79	1.15	0.06	7	627.79
Ψ(Impervious1900)	645.11	4.47	0.01	7	631.11
Ψ(Impervious2000)	645.15	4.51	0.01	7	631.15
Ψ(.)	667.15	26.51	0.00	6	655.15

Appendix 8.g Green Frog Effective Mesh Size AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Mesh2000)	639.36	0.00	0.13	7	625.36
Ψ(Mesh1900)	639.54	0.18	0.12	7	625.54
Ψ(Mesh1700)	639.84	0.49	0.10	7	625.84
Ψ(Mesh1800)	639.88	0.52	0.10	7	625.88
Ψ(MeshLN1700)	640.54	1.18	0.07	7	626.54
Ψ(MeshLN1500)	640.59	1.23	0.07	7	626.59
Ψ(MeshLN1600)	640.86	1.50	0.06	7	626.86
Ψ(Mesh1600)	640.87	1.52	0.06	7	626.87
Ψ(Mesh1500)	641.60	2.24	0.04	7	627.60
Ψ(MeshLN1800)	641.65	2.29	0.04	7	627.65
Ψ(MeshLN1400)	641.86	2.50	0.04	7	627.86
Ψ(MeshLN1900)	642.07	2.71	0.03	7	628.07
Ψ(MeshLN2000)	642.59	3.24	0.03	7	628.59
Ψ(MeshLN1300)	642.74	3.38	0.02	7	628.74
Ψ(Mesh1400)	643.37	4.01	0.02	7	629.37
Ψ(MeshLN1200)	643.59	4.23	0.02	7	629.59
Ψ(.)	667.15	27.79	0.00	6	655.15

Appendix 8 continued.

Appendix 8.h Green Frog Highway Density AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Hwy2000)	665.95	0.00	0.17	7	651.95
Ψ(Hwy1900)	666.67	0.71	0.12	7	652.67
Ψ(Hwy1700)	666.70	0.74	0.12	7	652.70
Ψ(Hwy1800)	666.80	0.84	0.11	7	652.80
Ψ(Hwy1600)	667.12	1.16	0.10	7	653.12
Ψ(.)	667.15	1.19	0.10	6	655.15
Ψ(Hwy1500)	667.60	1.64	0.08	7	653.60
Ψ(Hwy1400)	667.95	2.00	0.06	7	653.95
Ψ(Hwy1200)	668.59	2.63	0.05	7	654.59
Ψ(Hwy1300)	668.62	2.66	0.05	7	654.62
Ψ(Hwy1100)	668.74	2.78	0.04	7	654.74

Appendix 8.i Green Frog Percent Wetland Cover AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Wet1500)	662.66	0.00	0.12	7	648.66
Ψ(Wet1700)	662.81	0.15	0.11	7	648.81
Ψ(Wet1400)	662.88	0.22	0.11	7	648.88
Ψ(Wet1600)	662.95	0.28	0.11	7	648.95
Ψ(Wet1800)	663.61	0.95	0.08	7	649.61
Ψ(Wet1300)	663.87	1.21	0.07	7	649.87
Ψ(Wet1900)	664.26	1.60	0.06	7	650.26
Ψ(Wet2000)	664.42	1.75	0.05	7	650.42
Ψ(WetLN1600)	664.81	2.14	0.04	7	650.81
Ψ(Wet1200)	664.84	2.18	0.04	7	650.84
Ψ(WetLN1500)	665.05	2.39	0.04	7	651.05
Ψ(Wet1100)	665.30	2.63	0.03	7	651.30
Ψ(WetLN1700)	665.32	2.65	0.03	7	651.32
Ψ(WetLN1400)	666.35	3.69	0.02	7	652.35
Ψ(WetLN1300)	666.68	4.02	0.02	7	652.68
Ψ(WetLN1800)	666.72	4.06	0.02	7	652.72
Ψ(.)	667.15	4.49	0.01	6	655.15

Appendix 8 continued.

Appendix 8.j Green Frog Local Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(PerCan)	658.18	0.00	0.34	7	644.18
Ψ(PerCan,Area)	659.34	1.16	0.19	8	643.34
Ψ(PerCan,Peri)	659.40	1.22	0.19	8	643.40
Ψ(PerCan,SiteType)	660.18	2.00	0.13	8	644.18
Ψ(PerCan,Area,SiteType)	661.33	3.15	0.07	9	643.33
Ψ(PerCan,Peri,SiteType)	661.40	3.22	0.07	9	643.40
Ψ(.)	667.15	8.97	0.00	6	655.15

Appendix 8.k Green Frog Migration Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(For1000,ForClump1000,StrDen500)	637.66	0.00	0.38	9	619.66
Ψ(For1000,ForClump1000)	638.87	1.20	0.21	8	622.87
Ψ(For1000,StrDen500)	639.44	1.77	0.15	8	623.44
Ψ(ForClump1000,StrDen500)	639.95	2.29	0.12	8	623.95
Ψ(For1000)	640.19	2.53	0.11	7	626.19
Ψ(ForClump1000)	642.16	4.50	0.04	7	628.16
Ψ(.)	667.15	29.49	0.00	6	655.15

Appendix 8.l Green Frog Dispersal Scale AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(Mesh2000,Hwy2000)	636.69	0.00	0.44	8	620.69
Ψ(Wet1500,Mesh2000,Hwy2000)	638.32	1.63	0.19	9	620.32
Ψ(Mesh2000)	639.36	2.66	0.12	7	625.36
Ψ(ImperviousLN1400)	640.64	3.95	0.06	7	626.64
Ψ(Wet1500,Mesh2000)	640.80	4.11	0.06	8	624.80
Ψ(ImperviousLN1400,Wet1500)	641.07	4.38	0.05	8	625.07
Ψ(ImperviousLN1400,Hwy2000)	641.27	4.57	0.04	8	625.27
Ψ(.)	667.15	30.46	0.00	6	655.15

Appendix 8.m Green Frog Multi-scale Model AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(PerCan,Area,ForClump1000,Mesh2000)	624.76	0.00	0.07	10	604.76
Ψ(PerCan,Area,ForClump1000,Mesh2000,Hwy2000)	624.76	0.01	0.07	11	602.76

Appendix 8 continued.

Ψ(PerCan,Area,ForClump1000,Wet1500,Mesh2000)	625.64	0.88	0.05	11	603.64
Ψ(PerCan,Area,ForClump1000,StrDen500,Mesh2000)	625.97	1.21	0.04	11	603.97
Ψ(PerCan,Area,ForClump1000,ImperviousLN1400)	626.09	1.33	0.04	10	606.09
Ψ(PerCan,Area,ForClump1000,ImperviousLN1400,Wet1500)	626.14	1.38	0.04	11	604.14
Ψ(PerCan,Peri,ForClump1000,Mesh2000)	626.41	1.65	0.03	10	606.41
Ψ(PerCan,Peri,ForClump1000,Mesh2000,Hwy2000)	626.64	1.89	0.03	11	604.64
Ψ(PerCan,Area,SiteType,ForClump1000,Mesh2000)	626.76	2.00	0.03	11	604.76
Ψ(PerCan,Peri,ForClump1000,StrDen500,Mesh2000)	626.92	2.16	0.02	11	604.92
Ψ(PerCan,ForClump1000,Mesh2000,Hwy2000)	627.19	2.43	0.02	10	607.19
Ψ(PerCan,Area,ForClump1000,StrDen500,ImperviousLN1400)	627.40	2.64	0.02	11	605.40
Ψ(PerCan,Peri,ForClump1000,Wet1500,Mesh2000)	627.53	2.77	0.02	11	605.53
Ψ(PerCan,ForClump1000,Mesh2000)	627.58	2.82	0.02	9	609.58
Ψ(PerCan,Area,ForClump1000,ImperviousLN1400,Hwy2000)	627.72	2.96	0.02	11	605.72
Ψ(Area,ForClump1000,Mesh2000,Hwy2000)	627.93	3.17	0.02	10	607.93
Ψ(PerCan,Area,SiteType,ForClump1000,ImperviousLN1400)	628.00	3.24	0.01	11	606.00
Ψ(PerCan,Peri,ForClump1000,ImperviousLN1400)	628.01	3.25	0.01	10	608.01
Ψ(Area,ForClump1000,StrDen500,Mesh2000,Hwy2000)	628.11	3.35	0.01	11	606.11
Ψ(Area,ForClump1000,StrDen500,Mesh2000)	628.18	3.42	0.01	10	608.18
Ψ(PerCan,Peri,SiteType,ForClump1000,Mesh2000)	628.20	3.45	0.01	11	606.20
Ψ(PerCan,ForClump1000,ImperviousLN1400)	628.27	3.51	0.01	9	610.27
Ψ(PerCan,Peri,ForClump1000,ImperviousLN1400,Wet1500)	628.44	3.68	0.01	11	606.44
Ψ(PerCan,SiteType,ForClump1000,Mesh2000,Hwy2000)	628.49	3.73	0.01	11	606.49
Ψ(Area,ForClump1000,Mesh2000)	628.58	3.82	0.01	9	610.58
Ψ(PerCan,ForClump1000,Wet1500,Mesh2000,Hwy2000)	628.61	3.85	0.01	11	606.61
Ψ(PerCan,ForClump1000,Wet1500,Mesh2000)	628.69	3.93	0.01	10	608.69
Ψ(PerCan,ForClump1000,ImperviousLN1400,Wet1500)	628.73	3.97	0.01	10	608.73
Ψ(Area,ForClump1000,Wet1500,Mesh2000,Hwy2000)	628.79	4.03	0.01	11	606.79
Ψ(PerCan,ForClump1000,StrDen500,Mesh2000,Hwy2000)	628.89	4.13	0.01	11	606.89
Ψ(PerCan,ForClump1000,StrDen500,Mesh2000)	629.02	4.26	0.01	10	609.02
Ψ(Area,ForClump1000,Wet1500,Mesh2000)	629.04	4.28	0.01	10	609.04
Ψ(PerCan,Peri,ForClump1000,StrDen500,ImperviousLN1400)	629.05	4.29	0.01	11	607.05
Ψ(PerCan,SiteType,ForClump1000,Mesh2000)	629.31	4.55	0.01	10	609.31
Ψ(.)	667.15	42.39	0.00	6	655.15

Appendix 9 Northern cricket frog AIC model selection results for the analysis of occupancy. All candidate models within confidence set, 10% of the highest Akaike weight, are displayed, as well as the "null" model without covariates. Ψ is the occupancy probability and p is the detection probability. Covariate names followed by a numerical value indicate the covariates extent, a LN indicates a pseudo-threshold relationship, and INT indicates an interaction term was included. Covariate names are: Background Noise Index = **Noise**, Beaufort Wind Score = **Beau**, Days Since Rain = **DaysRain**, Days Since Above Average Rain of Survey Period = **DaysAvgRain**, Sky and Weather Condition = **Sky**, Time of Day = **Time**, Time since Sunset = **Sunset**, Julian Date = **Jul**, Julian Date Quadratic Term = **JulSq**, Temperature = **Temp**, Wind Speed = **Wind**, Percent Canopy = **PerCan**, Site Area = **Area**, Site Perimeter = **Peri**, Site Classification = **SiteType**, Percent Forest Cover = **For**, Forest Clumpiness Index = **ForClump**, Stream Density = **StrDen**, Percent NLCD Impervious Surface = **Impervious**, Effective Mesh Size = **Mesh**, Highway Density = **Hwy**, and Percent Wetland Cover = **Wet**.

Appendix 9.a Northern Cricket Frog Survey-specific Covariates AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(.)p(Jul,Sky1,Sky2thru4Com)	413.20	0.00	0.04	5	403.20
Ψ(.)p(Jul,Noise1,Noise2,Noise3and4Com)	413.31	0.11	0.03	6	401.31
Ψ(.)p(Jul)	413.46	0.26	0.03	3	407.46
Ψ(.)p(Sky1,Sky2thru4Com,Jul,JulSq)	413.99	0.79	0.02	6	401.99
Ψ(.)p(Jul,JulSq)	414.45	1.25	0.02	4	406.45
Ψ(.)p(Jul,Sky1,Sky2thru4Com,DaysRainLN)	414.64	1.44	0.02	6	402.64
Ψ(.)p(Temp,Jul)	414.68	1.48	0.02	4	406.68
Ψ(.)p(Temp,Jul,Sky1,Sky2thru4Com)	414.71	1.51	0.02	6	402.71
Ψ(.)p(Jul,DaysAvgRain)	414.82	1.62	0.02	4	406.82
Ψ(.)p(Jul,DaysAvgRain,Sky1,Sky2thru4Com)	414.92	1.73	0.02	6	402.92
Ψ(.)p(Jul,Sky1,Sky2thru4Com,SunsetLN)	415.05	1.85	0.01	6	403.05
Ψ(.)p(Jul,Sky1,Sky2thru4Com,DaysAvgRainLN)	415.10	1.91	0.01	6	403.10
Ψ(.)p(Jul,Sunset,Sky1,Sky2thru4Com)	415.11	1.91	0.01	6	403.11
Ψ(.)p(Jul,Sunset)	415.15	1.95	0.01	4	407.15
Ψ(.)p(Jul,Time,Sky1,Sky2thru4Com)	415.15	1.95	0.01	6	403.15
Ψ(.)p(Jul,Sky1,Sky2thru4Com,TimeLN)	415.18	1.98	0.01	6	403.18
Ψ(.)p(Jul,DaysRain,Sky1,Sky2thru4Com)	415.19	1.99	0.01	6	403.19
Ψ(.)p(Jul,Wind,Sky1,Sky2thru4Com)	415.20	2.00	0.01	6	403.20
Ψ(.)p(Jul,DaysAvgRainLN)	415.20	2.00	0.01	4	407.20
Ψ(.)p(Jul,Time)	415.23	2.03	0.01	4	407.23
Ψ(.)p(Jul,DaysRainLN)	415.26	2.06	0.01	4	407.26
Ψ(.)p(Jul,TimeLN)	415.28	2.08	0.01	4	407.28
Ψ(.)p(Jul,SunsetLN)	415.43	2.23	0.01	4	407.43
Ψ(.)p(Jul,DaysRain)	415.45	2.25	0.01	4	407.45
Ψ(.)p(Jul,Wind)	415.46	2.26	0.01	4	407.46
Ψ(.)p(Temp,Jul,DaysAvgRain)	415.85	2.65	0.01	5	405.85
Ψ(.)p(DaysAvgRain,Jul,JulSq)	415.91	2.71	0.01	5	405.91
Ψ(.)p(Jul,JulSq,DaysRainLN)	415.96	2.76	0.01	5	405.96

Appendix 9 continued.

Ψ(.)p(Sunset,Jul,JulSq)	416.11	2.91	0.01	5	406.11
Ψ(.)p(Time,Jul,JulSq)	416.14	2.94	0.01	5	406.14
Ψ(.)p(Temp,Jul,JulSq)	416.16	2.96	0.01	5	406.16
Ψ(.)p(Jul,JulSq,TimeLN)	416.19	2.99	0.01	5	406.19
Ψ(.)p(Temp,Jul,DaysAvgRainLN)	416.21	3.01	0.01	5	406.21
Ψ(.)p(Jul,JulSq,DaysAvgRainLN)	416.29	3.09	0.01	5	406.29
Ψ(.)p(Jul,JulSq,SunsetLN)	416.39	3.19	0.01	5	406.39
Ψ(.)p(DaysRain,Jul,JulSq)	416.43	3.23	0.01	5	406.43
Ψ(.)p(Temp,Jul,Sunset)	416.45	3.25	0.01	5	406.45
Ψ(.)p(Wind,Jul,JulSq)	416.45	3.25	0.01	5	406.45
Ψ(.)p(Temp,Jul,Time)	416.50	3.30	0.01	5	406.50
Ψ(.)p(Temp,Jul,TimeLN)	416.54	3.34	0.01	5	406.54
Ψ(.)p(Temp,Jul,DaysRainLN)	416.58	3.38	0.01	5	406.58
Ψ(.)p(Jul,DaysAvgRain,Sunset)	416.59	3.39	0.01	5	406.59
Ψ(.)p(Temp,Jul,SunsetLN)	416.62	3.42	0.01	5	406.62
Ψ(.)p(Temp,Jul,DaysRain)	416.63	3.43	0.01	5	406.63
Ψ(.)p(Jul,DaysAvgRain,Time)	416.66	3.46	0.01	5	406.66
Ψ(.)p(Temp,Jul,Wind)	416.68	3.48	0.01	5	406.68
Ψ(.)p(Jul,DaysAvgRain,TimeLN)	416.70	3.50	0.01	5	406.70
Ψ(.)p(Jul,DaysAvgRain,SunsetLN)	416.76	3.56	0.01	5	406.76
Ψ(.)p(Jul,Wind,DaysAvgRain)	416.82	3.62	0.01	5	406.82
Ψ(.)p(Jul,Sunset,DaysRainLN)	416.86	3.66	0.01	5	406.86
Ψ(.)p(Jul,Sunset,DaysAvgRainLN)	416.89	3.69	0.01	5	406.89
Ψ(.)p(Jul,Time,DaysRainLN)	416.96	3.76	0.01	5	406.96
Ψ(.)p(Jul,Time,DaysAvgRainLN)	416.98	3.78	0.01	5	406.98
Ψ(.)p(Jul,DaysRainLN,TimeLN)	417.01	3.81	0.01	5	407.01
Ψ(.)p(Jul,DaysAvgRainLN,TimeLN)	417.02	3.82	0.01	5	407.02
Ψ(.)p(Jul,Beau1,Beau2,Beau3)	417.09	3.89	0.01	6	405.09
Ψ(.)p(Jul,DaysRain,Sunset)	417.14	3.94	0.01	5	407.14
Ψ(.)p(Jul,Wind,Sunset)	417.15	3.95	0.01	5	407.15
Ψ(.)p(Jul,DaysAvgRainLN,SunsetLN)	417.17	3.97	0.01	5	407.17
Ψ(.)p(Jul,Wind,DaysAvgRainLN)	417.20	4.00	0.00	5	407.20
Ψ(.)p(Jul,DaysRain,Time)	417.23	4.03	0.00	5	407.23
Ψ(.)p(Jul,Wind,Time)	417.23	4.03	0.00	5	407.23
Ψ(.)p(Jul,DaysRainLN,SunsetLN)	417.25	4.05	0.00	5	407.25
Ψ(.)p(Jul,Wind,DaysRainLN)	417.26	4.06	0.00	5	407.26
Ψ(.)p(Jul,DaysRain,TimeLN)	417.27	4.07	0.00	5	407.27
Ψ(.)p(Jul,Wind,TimeLN)	417.28	4.08	0.00	5	407.28
Ψ(.)p(Jul,DaysRain,SunsetLN)	417.41	4.21	0.00	5	407.41

Appendix 9 continued.

Ψ(.)p(Jul,Wind,SunsetLN)	417.43	4.23	0.00	5	407.43
Ψ(.)p(Jul,Wind,DaysRain)	417.45	4.25	0.00	5	407.45
Ψ(.)p(Temp,DaysAvgRain,Jul,JulSq)	417.48	4.28	0.00	6	405.48
Ψ(.)p(Sunset,Jul,JulSq,DaysRainLN)	417.50	4.30	0.00	6	405.50
Ψ(.)p(Time,Jul,JulSq,DaysRainLN)	417.52	4.32	0.00	6	405.52
Ψ(.)p(Jul,JulSq,DaysRainLN,TimeLN)	417.58	4.38	0.00	6	405.58
Ψ(.)p(DaysAvgRain,Sunset,Jul,JulSq)	417.65	4.45	0.00	6	405.65
Ψ(.)p(DaysAvgRain,Time,Jul,JulSq)	417.67	4.47	0.00	6	405.67
Ψ(.)p(Temp,Jul,DaysAvgRain,Sunset)	417.70	4.50	0.00	6	405.70
Ψ(.)p(DaysAvgRain,Jul,JulSq,TimeLN)	417.72	4.52	0.00	6	405.72
Ψ(.)p(Temp,Jul,DaysAvgRain,SunsetLN)	417.74	4.54	0.00	6	405.74
Ψ(.)p(Temp,Jul,DaysAvgRain,Time)	417.74	4.54	0.00	6	405.74
Ψ(.)p(Temp,Jul,DaysAvgRain,TimeLN)	417.77	4.57	0.00	6	405.77

Appendix 9.b Northern Cricket Frog Percent Forest Cover AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(For900)	386.09	0.00	0.18	6	374.09
Ψ(For1000)	386.16	0.07	0.18	6	374.16
Ψ(For800)	387.31	1.22	0.10	6	375.31
Ψ(ForLN900)	387.35	1.26	0.10	6	375.35
Ψ(ForLN1000)	387.50	1.41	0.09	6	375.50
Ψ(ForLN800)	388.23	2.14	0.06	6	376.23
Ψ(For700)	388.78	2.69	0.05	6	376.78
Ψ(ForLN700)	388.89	2.80	0.04	6	376.89
Ψ(ForLN600)	389.09	2.99	0.04	6	377.09
Ψ(ForLN400)	389.36	3.27	0.04	6	377.36
Ψ(For600)	389.58	3.49	0.03	6	377.58
Ψ(ForLN500)	389.60	3.51	0.03	6	377.60
Ψ(For500)	390.22	4.13	0.02	6	378.22
Ψ(.)	413.20	27.11	0.00	5	403.20

Appendix 9.c Northern Cricket Frog Forest Clumpiness Index AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ForClump1000)	396.69	0.00	0.76	6	384.69
Ψ(ForClump900)	400.62	3.93	0.11	6	388.62
Ψ(.)	413.20	16.51	0.00	5	403.20

Appendix 9 continued.

Appendix 9.d Northern Cricket Frog Percent Forest Cover/Clumpiness Interaction AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(For900)	386.09	0.00	0.11	6	374.09
Ψ(For1000)	386.16	0.07	0.10	6	374.16
Ψ(For1000,ForClump1000)	386.87	0.78	0.07	7	372.87
Ψ(For800)	387.31	1.22	0.06	6	375.31
Ψ(ForLN900)	387.35	1.26	0.06	6	375.35
Ψ(ForLN1000)	387.50	1.41	0.05	6	375.50
Ψ(For900,ForClump900)	387.76	1.67	0.05	7	373.76
Ψ(ForLN800)	388.23	2.14	0.04	6	376.23
Ψ(ForLN1000,ForClump1000)	388.63	2.54	0.03	7	374.63
Ψ(For700)	388.78	2.69	0.03	6	376.78
Ψ(For1000,ForClump1000,ForClumpINT1000)	388.87	2.78	0.03	8	372.87
Ψ(ForLN700)	388.89	2.80	0.03	6	376.89
Ψ(ForLN600)	389.09	2.99	0.02	6	377.09
Ψ(For800,ForClump800)	389.22	3.12	0.02	7	375.22
Ψ(ForLN900,ForClump900)	389.23	3.14	0.02	7	375.23
Ψ(ForLN400)	389.36	3.27	0.02	6	377.36
Ψ(For600)	389.58	3.49	0.02	6	377.58
Ψ(ForLN500)	389.60	3.51	0.02	6	377.60
Ψ(For900,ForClump900,ForClumpINT900)	389.64	3.54	0.02	8	373.64
Ψ(For500)	390.22	4.13	0.01	6	378.22
Ψ(ForLN800,ForClump800)	390.23	4.14	0.01	7	376.23
Ψ(ForLN1000,ForClump1000,ForClumpINTLN1000)	390.44	4.35	0.01	8	374.44
Ψ(For700,ForClump700)	390.51	4.42	0.01	7	376.51
Ψ(For800,ForClump800,ForClumpINT800)	390.65	4.56	0.01	8	374.65
Ψ(.)	413.20	27.11	0.00	5	403.20

Appendix 9.e Northern Cricket Frog Stream Density AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(StrDen700)	411.90	0.00	0.17	6	399.90
Ψ(StrDen800)	412.45	0.55	0.13	6	400.45
Ψ(StrDen600)	412.74	0.83	0.11	6	400.74
Ψ(StrDen1000)	412.89	0.99	0.10	6	400.89
Ψ(StrDen900)	413.00	1.10	0.10	6	401.00
Ψ(StrDen500)	413.15	1.24	0.09	6	401.15

Appendix 9 continued.

Ψ(.)	413.20	1.30	0.09	5	403.20
Ψ(StrDen400)	414.04	2.14	0.06	6	402.04
Ψ(StrDen200)	414.31	2.41	0.05	6	402.31
Ψ(StrDen300)	414.33	2.43	0.05	6	402.33
Ψ(StrDen100)	414.72	2.81	0.04	6	402.72

Appendix 9.f Northern Cricket Frog Percent Impervious Impervious Surface AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(ImperviousLN1100)	372.01	0.00	0.18	6	360.01
Ψ(ImperviousLN1200)	372.22	0.20	0.16	6	360.22
Ψ(ImperviousLN1300)	372.46	0.44	0.14	6	360.46
Ψ(ImperviousLN1400)	372.97	0.96	0.11	6	360.97
Ψ(ImperviousLN1500)	373.48	1.47	0.09	6	361.48
Ψ(ImperviousLN1600)	373.52	1.51	0.08	6	361.52
Ψ(ImperviousLN1700)	374.08	2.07	0.06	6	362.08
Ψ(ImperviousLN1800)	374.63	2.62	0.05	6	362.63
Ψ(ImperviousLN2000)	374.96	2.94	0.04	6	362.96
Ψ(ImperviousLN1900)	375.00	2.98	0.04	6	363.00
Ψ(.)	413.20	41.19	0.00	5	403.20

Appendix 9.g Northern Cricket Frog Effective Mesh Size AIC Table

Model	**AIC**	Δ_i	w_i	**K**	**-2L**
Ψ(MeshLN1500)	377.97	0.00	0.11	6	365.97
Ψ(MeshLN1400)	378.01	0.04	0.11	6	366.01
Ψ(MeshLN1600)	378.25	0.28	0.10	6	366.25
Ψ(MeshLN1300)	378.25	0.28	0.10	6	366.25
Ψ(MeshLN1700)	378.56	0.59	0.09	6	366.56
Ψ(MeshLN1200)	378.76	0.79	0.08	6	366.76
Ψ(MeshLN1100)	379.64	1.67	0.05	6	367.64
Ψ(MeshLN1800)	380.02	2.06	0.04	6	368.02
Ψ(Mesh1500)	380.08	2.11	0.04	6	368.08
Ψ(Mesh1600)	380.14	2.17	0.04	6	368.14
Ψ(Mesh1400)	380.17	2.20	0.04	6	368.17
Ψ(Mesh1700)	380.20	2.23	0.04	6	368.20
Ψ(Mesh1300)	380.38	2.41	0.03	6	368.38
Ψ(MeshLN1900)	380.77	2.80	0.03	6	368.77

Appendix 9 continued.

Ψ(Mesh1200)	380.97	3.00	0.03	6	368.97
Ψ(Mesh1800)	381.25	3.28	0.02	6	369.25
Ψ(MeshLN2000)	381.76	3.79	0.02	6	369.76
Ψ(Mesh1900)	381.79	3.82	0.02	6	369.79
Ψ(Mesh1100)	382.15	4.19	0.01	6	370.15
Ψ(Mesh2000)	382.41	4.44	0.01	6	370.41
Ψ(.)	413.20	35.23	0.00	5	403.20

Appendix 9.h Northern Cricket Frog Highway Density AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(Hwy2000)	388.40	0.00	0.41	6	376.40
Ψ(Hwy1900)	390.09	1.69	0.17	6	378.09
Ψ(Hwy1700)	390.41	2.01	0.15	6	378.41
Ψ(Hwy1800)	390.52	2.12	0.14	6	378.52
Ψ(Hwy1600)	391.61	3.21	0.08	6	379.61
Ψ(.)	413.20	24.80	0.00	5	403.20

Appendix 9.i Northern Cricket Frog Percent Wetland Cover AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(WetLN1500)	397.24	0.00	0.20	6	385.24
Ψ(WetLN1700)	398.74	1.50	0.09	6	386.74
Ψ(WetLN1600)	399.05	1.81	0.08	6	387.05
Ψ(WetLN1400)	399.26	2.02	0.07	6	387.26
Ψ(Wet1500)	399.27	2.03	0.07	6	387.27
Ψ(Wet1400)	399.75	2.51	0.06	6	387.75
Ψ(Wet2000)	400.09	2.85	0.05	6	388.09
Ψ(WetLN1900)	400.31	3.06	0.04	6	388.31
Ψ(WetLN1800)	400.33	3.09	0.04	6	388.33
Ψ(Wet1900)	400.36	3.11	0.04	6	388.36
Ψ(Wet1600)	400.39	3.15	0.04	6	388.39
Ψ(WetLN1300)	400.39	3.15	0.04	6	388.39
Ψ(Wet1700)	400.43	3.19	0.04	6	388.43
Ψ(WetLN2000)	400.54	3.30	0.04	6	388.54
Ψ(Wet1800)	400.95	3.71	0.03	6	388.95
Ψ(Wet1300)	401.26	4.02	0.03	6	389.26
Ψ(WetLN1200)	401.68	4.44	0.02	6	389.68

Appendix 9 continued.

Ψ(.)	413.20	15.96	0.00	5	403.20

Appendix 9.j Northern Cricket Frog Local Scale AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(PerCan,Peri)	404.80	0.00	0.31	7	390.80
Ψ(PerCan,Area)	406.10	1.30	0.16	7	392.10
Ψ(PerCan)	406.11	1.30	0.16	6	394.11
Ψ(PerCan,Peri,SiteType)	406.78	1.98	0.12	8	390.78
Ψ(Peri)	407.87	3.06	0.07	6	395.87
Ψ(PerCan,SiteType)	408.02	3.22	0.06	7	394.02
Ψ(PerCan,Area,SiteType)	408.10	3.30	0.06	8	392.10
Ψ(.)	413.20	8.40	0.00	5	403.20

Appendix 9.k Northern Cricket Frog Migration Scale AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(For900,StrDen700)	384.93	0.00	0.35	7	370.93
Ψ(For900,ForClump1000,StrDen700)	385.10	0.17	0.32	8	369.10
Ψ(For900)	386.09	1.16	0.19	6	374.09
Ψ(For900,ForClump1000)	386.74	1.81	0.14	7	372.74
Ψ(.)	413.20	28.27	0.00	5	403.20

Appendix 9.l Northern Cricket Frog Dispersal Scale AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ImperviousLN1100,WetLN1500,Hwy2000)	365.60	0.00	0.61	8	349.60
Ψ(ImperviousLN1100,WetLN1500)	367.27	1.67	0.26	7	353.27
Ψ(ImperviousLN1100,Hwy2000)	369.67	4.06	0.08	7	355.67
Ψ(.)	413.20	47.60	0.00	5	403.20

Appendix 9.m Northern Cricket Frog Multi-scale Model AIC Table

Model	AIC	Δ_i	w_i	K	-2L
Ψ(ForClump1000,ImperviousLN1100,WetLN1500,Hwy2000)	361.00	0.00	0.07	9	343.00
Ψ(PerCan,ForClump1000,WetLN1500,Hwy2000)	361.21	0.21	0.06	9	343.21
Ψ(PerCan,ForClump1000,ImperviousLN1100,WetLN1500,Hwy2000)	361.45	0.46	0.06	10	341.45
Ψ(ForClump1000,StrDen700,ImperviousLN1100,WetLN1500,Hwy2000)	361.70	0.71	0.05	10	341.70

Appendix 9 continued.

Ψ(PerCan,SiteType,ForClump1000,WetLN1500,Hwy2000)	362.37	1.37	0.04	10	342.37
Ψ(PerCan,For900,ForClump1000,WetLN1500,Hwy2000)	362.37	1.38	0.04	10	342.37
Ψ(PerCan,ForClump1000,StrDen700,WetLN1500,Hwy2000)	362.38	1.38	0.04	10	342.38
Ψ(SiteType,ForClump1000,ImperviousLN1100,WetLN1500,Hwy2000)	362.46	1.46	0.03	10	342.46
Ψ(Area,ForClump1000,ImperviousLN1100,WetLN1500,Hwy2000)	362.64	1.64	0.03	10	342.64
Ψ(ForClump1000,WetLN1500,Hwy2000)	362.74	1.74	0.03	8	346.74
Ψ(For900,ForClump1000,WetLN1500,Hwy2000)	362.81	1.81	0.03	9	344.81
Ψ(PerCan,Area,ForClump1000,WetLN1500,Hwy2000)	362.84	1.85	0.03	10	342.84
Ψ(For900,ForClump1000,StrDen700,WetLN1500,Hwy2000)	362.85	1.85	0.03	10	342.85
Ψ(ForClump1000,StrDen700,WetLN1500,Hwy2000)	362.90	1.90	0.03	9	344.90
Ψ(Peri,ForClump1000,ImperviousLN1100,WetLN1500,Hwy2000)	362.92	1.93	0.03	10	342.92
Ψ(PerCan,ForClump1000,WetLN1500,MeshLN1500,Hwy2000)	363.10	2.11	0.02	10	343.10
Ψ(PerCan,Peri,ForClump1000,WetLN1500,Hwy2000)	363.19	2.19	0.02	10	343.19
Ψ(ForClump1000,WetLN1500,MeshLN1500,Hwy2000)	364.05	3.05	0.02	9	346.05
Ψ(Peri,ForClump1000,WetLN1500,Hwy2000)	364.33	3.34	0.01	9	346.33
Ψ(Peri,For900,ForClump1000,WetLN1500,Hwy2000)	364.35	3.35	0.01	10	344.35
Ψ(SiteType,For900,ForClump1000,WetLN1500,Hwy2000)	364.40	3.40	0.01	10	344.40
Ψ(ForClump1000,StrDen700,WetLN1500,MeshLN1500,Hwy2000)	364.56	3.57	0.01	10	344.56
Ψ(SiteType,ForClump1000,WetLN1500,Hwy2000)	364.60	3.60	0.01	9	346.60
Ψ(Area,ForClump1000,StrDen700,WetLN1500,Hwy2000)	364.62	3.63	0.01	10	344.62
Ψ(Area,ForClump1000,WetLN1500,Hwy2000)	364.68	3.68	0.01	9	346.68
Ψ(SiteType,ForClump1000,StrDen700,WetLN1500,Hwy2000)	364.72	3.73	0.01	10	344.72
Ψ(Area,For900,ForClump1000,WetLN1500,Hwy2000)	364.75	3.76	0.01	10	344.75
Ψ(Peri,ForClump1000,StrDen700,WetLN1500,Hwy2000)	364.87	3.87	0.01	10	344.87
Ψ(ImperviousLN1100,WetLN1500,Hwy2000)	365.60	4.60	0.01	8	349.60
Ψ(.)	413.20	52.20	0.00	5	403.20

BIBLIOGRAPHY

1. Aldridge C.L., S.E. Hanser, S.E. Nielsen, M. Leu, B.S. Cade, D.J. Saher, and S.T. Knick. 2011. Pages 141-220 in S.E.. Hanser, M. Leu, S.T. Knick, and C.L. Aldridge (editors). Sagebrush ecosystem conservation and management: ecoregional assessment tools and models for the Wyoming Basins. Allen Press, Lawrence, KS.
2. Alexander, S. M., N. M. Waters, and P. C. Paquet. 2005. Traffic volume and highway permeability for a mammalian community in the Canadian Rocky Mountains. Canadian Geographer-Geographe Canadien 49:321-331.
3. Bradford, D. F., A. C. Neale, M. S. Nash, D. W. Sada, and J. R. Jaeger. 2003. Habitat patch occupancy by toads (Bufo punctatus) in a naturally fragmented desert landscape. Ecology 84:1012–1023.
4. Bridges, A. S. and M. E. Dorcas. 2000. Temporal variation in anuran calling behavior: Implications for surveys and monitoring programs. Copeia:587-592.
5. Brown, D. G., K. M. Johnson, T. R. Loveland, and D. M. Theobald. 2005. Rural land-use trends in the conterminous United States, 1950-2000. Ecological Applications 15:1851-1863.
6. Buckland, S. T., R. E. Russell, B. G. Dickson, V. A. Saab, D. N. Gorman, and W. M. Block. 2009. Analyzing designed experiments in distance sampling. Journal of Agricultural, Biological, and Environmental Statistics 14:432-442.
7. Burnham K.P., Anderson D.R. 2002. Model selection and inference: a practical information-theoretic approach, 2nd edition. Springer, New York.
8. Cabeza, M., A. Arponen, L. Jaattela, H. Kujala, A. van Teeffelen, and I. Hanski. 2010. Conservation planning with insects at three different spatial scales. Ecography 33:54-63.
9. Castellon, T. D. and K. E. Sieving. 2006. An experimental test of matrix permeability and corridor use by an endemic understory bird. Conservation Biology 20:135-145.
10. Cowardin, L. M., V. Carter, F. C. Golet, E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 131pp.
11. Cushman, S. A. and K. McGarigal. 2002. Hierarchical, Multi-scale decomposition of species-environment relationships. Landscape Ecology 17:637-646.
12. Czech, B. 2004. Urbanization as a threat to biodiversity: Trophic theory, economic geography, and implications for conservation land acquisition. Pages 8-13 in D. N. Bengston, editor. Policies for Managing Urban Growth and Landscape Change: A Key to Conservation in the 21st Century. Us Dept Agr, Forest Serv, N Cent Res Stn, St Paul.
13. DeLong E.R., DeLong D.M., Clarke-Pearson D.L. 1988. Comparing the Areas Under Two or More Correlated Receiver Operating Characteristic. Biometrics 1988; 44:837-45.
14. Dorcas, M. E., S. J. Price, S. C. Walls, and W. J. Barichivich. 2009. Auditory monitoring of anuran populations. Pages 281-298 in J. D. Willson, J. W. Gibbons, and J. C. K. Dodd, editors. Amphibian Ecology and Conservation. Oxford University Press, , Oxford, UK.
15. Eigenbrod, F., S. J. Hecnar, and L. Fahrig. 2008. The relative effects of road traffic and forest cover on anuran populations. Biological Conservation 141:35-46.
16. ESRI. 2009. ArcMap 10.0. ESRI, Redlands, CA.
17. Fahrig, L. 1999. Forest loss and fragmentation: which has greater effect on persistence of of forest dwelling animals? Pages 87-95 in J. A. Rochelle, L. A. Lehmann, and J. Wisniewski, editors. Forest Fragmentation: Wildlife and Management Implications. Brill Academic Publishing, Leiden, The Neatherlands.
18. Finch, D. M. 1991. Population ecology, habitat requirements, and conservation of neotropical migratory birds. Gen. Tech. Rep. RM-205. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.
19. Franklin, A. B., D. R. Anderson, R. J. Gutierrez, and K. P. Burnham. 2000. Climate, habitat quality, and fitness in Northern Spotted Owl populations in northwestern California. Ecological Monographs 70:539-590.

20. Freemark, K., D. Bert, and M.A. Villard. 2002. Patch-, landscape-, and regional-scale effects on biota. Pages 58-83 in F. Gutzwiller, editor. Applying Landscape Ecology in Biological Conservation. Springer-Verlag, New York, NY.
21. Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, PE&RS, Vol. 77(9):858-864. National Land Cover Database retrieved January 2010, from http://www.mrlc.gov/.
22. Garrett, M. K. 2002. Virginia Frog and Toad Survey: Training Manual. J. Kleopfer, editor. Virginia Department of Game and Inland Fisheries, Richmond, VA.
23. Gilpin, M. E. and M. E. Soulé. 1986. Minimum viable populations: The processes of species extinctions.in M. E. Soulé, editor. Conservation Biology: The Science of Scarcity and Diversity. Sinauer Associates, Sunderland, MA.
24. Graf, R. F., K. Bollmann, W. Suter, and H. Bugmann. 2005. The importance of spatial scale in habitat models: capercaillie in the Swiss Alps. Landscape Ecology 20:703-717.
25. Hamer, A. J. and K. M. Parris. 2010. Local and landscape determinants of amphibian communities in urban ponds. Ecological Applications 21:378-390.Goodwin, B. J. and L. Fahrig. 2002. How does landscape structure influence landscape connectivity? Oikos 99:552-570.
26. Hines, J.E. (2006). Presence2- Software to estimate patch occupancy and related parameters. USGS-PWRC. http://www.mbr-pwrc.usgs.gov/software /presence.html.
27. Hosmer, D.W. and S. Lemeshow. 2000.Applied Logistic Regression. Second Edition. John Wiley and Sons, Inc., New York, NY.
28. Jaeger, J. A. G. 2000. Landscape division, splitting index, and effective mesh size: new measures of landscape fragmentation. Landscape Ecology 15:115-130.
29. Koivula, M. J. and H. J. W. Vermeulen. 2005. Highways and forest fragmentation - effects on carabid beetles (Coleoptera, Carabidae). Landscape Ecology 20:911-926.
30. Levin, S. A. 1992. The Problem of Pattern and Scale in Ecology: The Robert H. MacArthur Award Lecture. Ecology (Durham) 73:1943-1967.
31. Lindenmayer, D., R. J. Hobbs, R. Montague-Drake, J. Alexandra, A. Bennett, M. Burgman, P. Cale, A. Calhoun, V. Cramer, P. Cullen, D. Driscoll, L. Fahrig, J. Fischer, J. Franklin, Y. Haila, M. Hunter, P. Gibbons, S. Lake, G. Luck, C. MacGregor, S. McIntyre, R. Mac Nally, A. Manning, J. Miller, H. Mooney, R. Noss, H. Possingham, D. Saunders, F. Schmiegelow, M. Scott, D. Simberloff, T. Sisk, G. Tabor, B. Walker, J. Wiens, J. Woinarski, and E. Zavaleta. 2008. A checklist for ecological management of landscapes for conservation. Ecology Letters 11:78-91.
32. MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248-2255.
33. MacKenzie, D., and L. Bailey. 2004. Assessing fit of site occupancy models. Journal of Agricultural, Biological and Ecological Statistics 9:300-318.
34. MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy Estimation and Modeling: Inferring Patterns and Dynamics of Species Occurrence. Academic Press, Elsevier, San Diego, CA.
35. Mazerolle, M. J., A. Desrochers, and L. Rochefort. 2005. Landscape characteristics influence pond occupancy by frogs after accounting for detectability. Ecological Applications 15:824-834.
36. McGarigal, K., SA Cushman, and E Ene. 2012. FRAGSTATS v4: Spatial Pattern Analysis Program for Categorical and Continuous Maps. Computer software program produced by the authors at the University of Massachusetts, Amherst. Available at the following web site: http://www.umass.edu/landeco/research/fragstats/fragstats.html.
37. McCown, J. W., P. Kubilis, T. H. Eason, and B. K. Scheick. 2009. Effect of traffic volume on American black bears in central Florida, USA. Ursus 20:39-46.
38. Metz, C.E. 1978. Basic principles of ROC analysis. Seminars in Nuclear Medicine 8:283-298.
39. Moilanen, A. 2002. Implications of empirical data quality to metapopulation model parameter estimation and application. Oikos 96:516-530.
40. Moran, P. A. P. (1950). "Notes on Continuous Stochastic Phenomena". Biometrika 37 (1): 17–23.

41. Moser, B., J. A. G. Jaeger, U. Tappeiner, E. Tasser, and B. Eiselt. 2007. Modification of the effective mesh size for measuring landscape fragmentation to solve the boundary problem. Landscape Ecology 22:447-459.
42. Olson, D. M. and E. Dinerstein (2002). "The Global 200: Priority Ecoregions for Global Conservation." Annals of the Missouri Botanical Garden 89(2): 199-224.
43. Pope, S. E., L. Fahrig, and N. G. Merriam. 2000. Landscape complementation and metapopulation effects on leopard frog populations. Ecology 81:2498-2508.
44. Quinn, G. P. and M. J. Keough. 2009. Experimental Design and Data Analysis for Biologists. 8th edition. Cambridge University Press, Cambridge, United Kingdom.
45. R Development Core Team (2008). R: A language and environment for statistical computing. R Foundation for Statistical Computing,Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.
46. Radeloff, V. C., R. B. Hammer, S. I. Stewart, J. S. Fried, S. S. Holocomb, and J. F. McKeefry. 2005. The wildland-urban interface in the United States. Ecological Applications 15:799-805.
47. Razgour, O., J. Hanmer, and G. Jones. 2011. Using multi-scale modelling to predict habitat suitability for species of conservation concern: The grey long-eared bat as a case study. Biological Conservation 144:2922-2930.
48. Robinson, L., J. P. Newell, and J. M. Marzluff. 2005. Twenty-five years of sprawl in the Seattle region: growth management responses and implications for conservation. Landscape and Urban Planning 71:51-72.
49. Rubbo, M. J. and J. M. Kiesecker. 2005. Amphibian Breeding Distribution in an Urbanized Landscape. Conservation Biology 19:504-511.
50. Ruggiero, L. F., G. D. Hayward, and J. R. Squires. 1994. Viability analysis in biological evaluations - concepts of population viability analysis, biological population, and ecological scale. Conservation Biology 8:364-372.
51. SE GAP. 2010. "segap_13oct10." Biodiversity and Spatial Information Center, USGS North Carolina Cooperative Fish and Wildlife Research Unit, NC State University. Retrieved October 2010, from http://www.basic.ncsu.edu/segap/.
52. Sandel, B. and A. B. Smith. 2009. Scale as a lurking factor: incorporating scale-dependence in experimental ecology. Oikos 118:1284-1291.
53. Scherer, R., E. Muths, and B. Noon. 2012. The importance of local and landscape-scale processes to the occupancy of wetlands by pond-breeding amphibians. Population Ecology:1-12.
54. Seaber, P. R., F. P. Kapinos, and G. L. Knapp. 1987. Hydrologic Unit Maps. U.S. Geological Survey Water-Supply Paper 2294:1-63.
55. Semlitsch, R. D. (2008). "Differentiating migration and dispersal processes for pond-breeding amphibians." Journal of Wildlife Management 72(1): 260-267.
56. Semlitsch, R. D. and J. R. Bodie. 2003. Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. Conservation Biology 17:1219-1228.
57. Sisk, T. D., A. E. Launer, K. R. Switky, and P. R. Ehrlich. 1994. Identifying extinction threats. BioScience 44:592-604.
58. Smith, M. A. and D. M. Green. 2005. Dispersal and the metapopulation paradigm in amphibian ecology and conservation: are all amphibian populations metapopulations? Ecography 28:110-128.
59. Taylor, P. D., L. Fahrig, K. Henein, and G. Merriam. 1993. Connectivy is a vital element of landscape structure. Oikos 68:571-573.
60. TIGER/Line Shapefiles. 2010. [machine-readable data files]/prepared by the U.S. Census Bureau.
61. Tracy, C. R., K. A. Christian, and M. P. Oconnor. 1993. Behavioral thermoregulation by Bufo-americanus - the importance of the hydric environment. Herpetologica 49:375-382.
62. Turner, M. G. 1989. Landscape ecology: the effect of the pattern on process. Annual Review of Ecology and Systematics 20:171-197.
63. Tyre, A. J., B. Tenhumberg, S. A. Field, D. Niejalke, K. Parris, and H. P. Possingham. 2003. Improving precision and reducing bias in biological surveys: Estimating false-negative error rates. Ecological Applications 13:1790-1801.

64. Umetsu, F., J. P. Metzger, and R. Pardini. 2008. Importance of estimating matrix quality for modeling species distribution in complex tropical landscapes: a test with Atlantic forest small mammals. Ecography 31:359-370.
65. U.S. Census Bureau. 2010. US Gazetteer files. 2000. Retrieved January 2010, from http://www.census.gov/geo/maps-data/data/gazetteer.html.
66. U.S. Geological Survey. 2005. National Hydrography Dataset Plus – NHDPlus. Retrieved January 2010, from http://nhd.usgs.gov/.
67. U. S. Fish and Wildlife Service. 2010. National Wetlands Inventory website. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. from: http://www.fws.gov/wetlands/
68. Van Buskirk J (2005) Local and landscape influence on amphibian occurrence and abundance. Ecology 86:1936–1947.
69. Verbeylen, G., L. De Bruyn, F. Adriaensen, and E. Matthysen. 2003. Does matrix resistance influence Red squirrel (Sciurus vulgaris L. 1758) distribution in an urban landscape? Landscape Ecology 18:791-805.
70. Virginia Department of Game and Inland Fisheries. 2012. BOVA booklet. Retrieved November 2012, from http://vafwis.org/fwis/.
71. Virginia Information Technologies Agency. 2009. Virginia Base Mapping Program. Retrieved January 2010, from http://www.vita.virginia.gov/isp/default.aspx?id=8412.
72. Weir, L. A. and M. J. Mossman. 2005. North American Amphibian Monitoring Program (NAAMP). Pages 307-313 in M. J. Lannoo, editor. Amphibian Declines: conservation status of United States species. University of California Press.
73. Werner, E. E. and J. F. Gilliam. 1984. The ontogenetic niche and species interactions in size structured populations. Annual Review of Ecology and Systematics 15:393-425.
74. Wiens, J. A. 1989. Spatial Scaling in Ecology. Functional Ecology 3:385-397.
75. Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience 48:607-615.
76. Xavier Robin, Natacha Turck, Alexandre Hainard, Natalia Tiberti, Frédérique Lisacek, Jean-Charles Sanchez and Markus Müller (2011). “pROC: an open-source package for R and S+ to analyze and compare ROC curves”. BMC Bioinformatics, 12, p. 77.
Zuur, A. F., E. N. Ieno, and C. S. Elphick. 2010. A protocol for data exploration to avoid common statistical problems. Methods in Ecology and Evolution 1:3-14.